Wolf Biology and Management in Alaska 1981-92

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Wolves remain widely distributed throughout their historic range in Alaska; the population is estimated at 5,900–7,200 and numbers have generally increased in recent years. Numerous long-range movements of dispersing wolves between regions in Alaska and Canada have been documented, emphasizing the mobility of wolves and potential for genetic exchange. Research during the decade continued to demonstrate the important role predation by wolves and bears often plays in ungulate population dynamics, sometimes contributing to chronically low densities. Predation by both black and brown bears is a major source of ungulate mortality in much of Alaska, particularly for moose calves. The effects of bear predation continued to confound the issue of wolf management. Although the past decade was marked by significant advances in understanding the ecology of wolves and their prey, controversy and litigation continued to characterize the management of wolves. Legal and political controversies focused on proposals for wolf reduction and the use of aircraft in hunting and trapping wolves. A process that sought to involve all segments of the public in the development of a statewide plan helped move wolf management in a more constructive direction.

Introduction

Harbo and Dean (1983) reviewed the history of wolf (*Canis lupus*) population status and management in Alaska through 1980. They described five major phases during this century: a period of indiscriminate and largely unsuccessful wolf control efforts prior to World War II; a period of intense federally sponsored control during the 1950's that significantly lowered wolf numbers in several areas of the state; a transitional phase between federal and state management during which biologists in the emerging Alaska Department of Fish and Game (ADF&G) increasingly challenged the need for federal wolf control in view of high (often excessive) ungulate numbers; a period following full state assumption of management authority in 1960 when wolves were reclassified from vermin to fur and game animals and all control efforts were halted; and finally a period of turmoil beginning in the early 1970's when ADF&G proposed limited control efforts in a few small areas following recovery of the wolf population and declines in prey numbers.

Rausch and Hinman (1977) also discussed changes in government policy and public perception of wolves and suggested that the future of wolf management in Alaska was uncertain because of strongly polarized views in the public. Harbo and Dean (1983) were more optimistic, concluding that professional and public attitudes had moderated in the face of improved knowledge of the impacts of wolf predation, and that litigation during the late 1970's had largely settled the issue of agency authority to implement wolf control programs. They also predicted that, "Wolf control will continue to become more of an operational process for ADF&G..." and expressed the hope that "...the future will be characterized by substantially increased knowledge of basic ecology and significantly more effective and mutually sympathetic communication between the many interested segments of society."

Harbo and Dean's (1983) predictions have not been borne out during the ensuing decade and their hope for better communication appears to have been premature. Although research did expand scientific awareness of the effects of wolf predation on ungulate population dynamics, opposition to wolf control strengthened in some segments of society. While some biologists and members of the public began the decade viewing wolf control as a routine part of management programs, opponents of control rallied forces and developed new legal and political strategies. The 1980's were marked by continued litigation and acrimonious debate, often characterized by misinformation or selective use of information about wolf-prey relationships. Late in the decade, as the demands for broader public involvement in decision making increased, ADF&G launched an initiative to develop public consensus on wolf management. This planning effort was designed to bring together people with diverse views who share a common interest in the long-term conservation of wolves and their prey.

This paper reviews wolf research and management during the 1980's and discusses their relationship to public debate. It begins with a discussion of the status and trends of populations followed by a review of recently completed and on-going research into wolf ecology. Finally, it chronicles major developments in the evolution of wolf management policies during the 1980's and offers a prognosis for the future.

Wolf Population Status in Alaska, 1981-1991

During the 1980's the distribution and abundance of wolves remained fairly stable in Alaska, although some increases in distribution and numbers have occurred. Wolves continued to be regularly distributed over most of their original range, occupying at least 85% of the state's 1,517,740 km^2. Autumn population density in closely studied populations ranged from about two to 20 wolves/1,000 km^2 (Gasaway et al. 1983, 1992; Peterson et al. 1984; Ballard et al. 1987; Adams et al. 1989b; Mech et al. 1991). Wolves continue to be absent from areas which were not colonized after the last glacial recession, including the Aleutian, Kodiak, Admiralty, Baranof, and Chichagof Islands.

Radiotelemetry studies in Alaska and Yukon revealed that extensive movements of individuals and packs occur regularly (Fig. 1). Consequently, localized reductions due to human harvest of wolves are usually soon offset by immigration when harvest is reduced, and genetic exchange between regions appears to be common.

Although estimates of wolf numbers in Alaska were available prior to 1984, the methods and assumptions upon which they were based are unknown. In a review of wolf management in Alaska, Harper (1970) stated that, "A con-

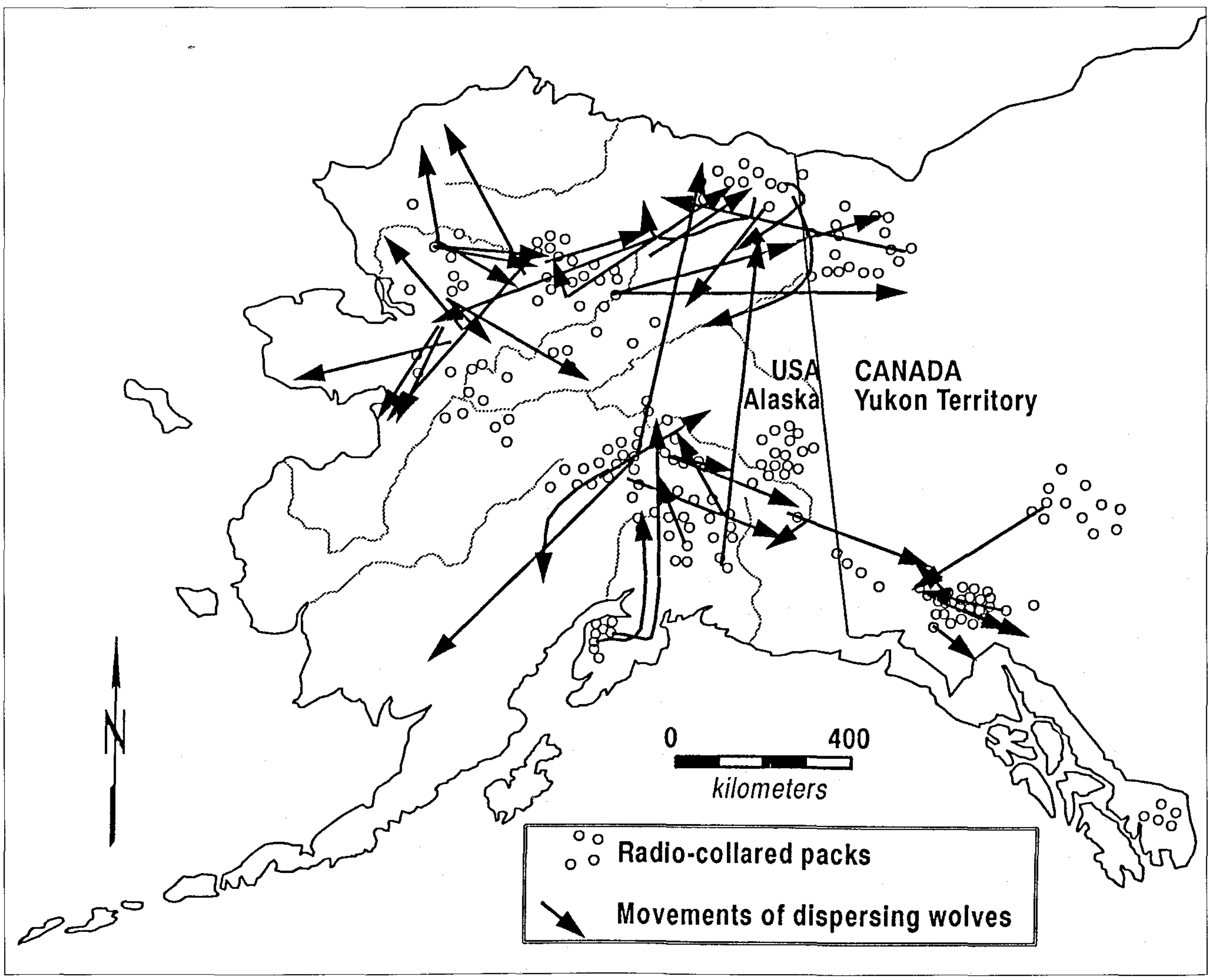

Fig. 1 *The general location of radio-marked wolf packs studied in Alaska and the adjacent Yukon from 1975 to 1991, and also the known long-range movements of dispersing wolves. Packs were monitored for periods of two to eight years. Principal sources of data include: Stephenson and James (1982), Ballard et al. (1983, 1987, 1990), Peterson et al. (1984), Weiler et al. (1986), Adams et al. (1989b), Mech et al. (1989, 1991), and Hayes et al. (1991).*

servative figure for the present statewide population is approximately 5,000 wolves." Mech and Rausch (1975) concluded:

> No accurate estimate of total numbers of wolves in Alaska is available. In the past, a qualified estimate of 5,000 wolves was made; it has crept into the literature and has been arbitrarily lowered or raised to suit the individual viewpoints being expressed. The estimate of 5,000 probably is extremely conservative. Whatever the case, wolves continue to exist throughout their historic range at very high population levels in most areas.

Skoog (1983) estimated Alaska's wolf population to be in excess of 10,000 animals. In addition to these published estimates, similar figures ranging from 6,000 to 10,000 appeared in ADF&G informational leaflets during the early 1980's, and figures of 15,000 or higher were cited in popular literature during the late 1970's and early 1980's.

Unfortunately, wolf protection groups have compared the highest estimates with ADF&G's current estimates, suggesting that wolf numbers have declined by as much as 50% since the 1970's. While this alarmed some people who are not well informed about wolves, there is no validity in comparing these numbers in view of the unknown and highly subjective basis for estimates prior to 1984.

In 1984, ADF&G began assembling systematic annual estimates of wolf numbers (expressed as a minimum and maximum for most areas) on a Game Management Unit (GMU) basis (Fig. 2), which also yielded a statewide total. These estimates are derived from aerial wolf surveys, telemetry studies in limited areas, and sightings of wolves and wolf tracks provided by pilots, trappers, and other members of the public. In a few areas in coastal and southeastern Alaska, where terrain or weather limit the usefulness of conventional survey techniques, estimates are based on extrapolations from adjacent areas with similar habitat and prey availability. While the accuracy and precision of the estimates vary depending on the basis for the estimate, these figures are generally accepted as the most reasonable available.

In winter 1989-90 the ADF&G estimated the statewide wolf population to be 5,900–7,200 wolves in 700–900 packs. Aerial surveys and telemetry studies suggest that numbers are stable or slightly increasing in most areas, with higher numbers being recorded in GMU's 6, 13, 19, 20, 21, and 24 (Morgan 1990a). These increases correspond with those in several caribou (*Rangifer tarandus*) herds (Davis and Valkenburg 1991) and some moose (*Alces alces*) (Ballard et al. 1991a) and Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) (Morgan 1990b) populations, combined with increased restrictions on wolf hunting and trapping. In other areas, such as GMU 24, an increase in estimated numbers is primarily the result of better data from intensive surveys or telemetry studies (Morgan 1990a).

While the total number of wolves in the state is of interest, annual changes in the statewide population estimate are of limited value in assessing the status of wolves. Increases in one region can be offset by decreases in another, and the varying quality and unknown direction of bias in some estimates limit the usefulness of the statewide total.

The status of wolves is best evaluated on a regional or local basis relative to prey density and availability and land use and resource management policies and objectives. With respect to prey availability, the status of wolves in Alaska can be viewed as falling into three general categories: 1) prey are abundant and wolf density is as high as can be sustained in view of ungulate density and productivity (e.g., the eastern and central Brooks Range where moose, caribou, and Dall sheep (*Ovis dalli*) are numerous and wolf harvest is generally low); 2) prey abundance is high and could support higher wolf populations, but total wolf mortality or other factors are preventing an increase in wolf numbers (e.g., parts of GMU's 7, 13, 14, 15, 16, 22, 23, and 26); and 3) areas where moose, caribou, or deer remain at chronically low densities due in part to wolf predation, and wolf densities remain low, despite little harvest (e.g., parts of eastern interior and southeastern Alaska).

Evaluating the status of wolves relative to land use and management objectives is difficult because these are, in many cases, in the process of being developed or revised. There has been virtually no reduction in habitat availability during the past decade. There is, however, a concern that wolf populations may decline in portions of southeastern Alaska as a result of an expanding road system, reduced habitat for Sitka black-tailed deer resulting from logging of old-growth forest, and reduced genetic variability and fitness as insular subpopulations decline (M. D. Kirchhoff, Alaska Dept. Fish and Game, Juneau, pers. commun.).

Wolf Research in Alaska, 1981–92

During the 1970's, ADF&G initiated studies to better evaluate the role of wolf predation in ungulate population dynamics. During this period, biologists were reevaluating the role of wolf predation in limiting ungulate populations. Several of these studies were mentioned by Harbo and Dean (1983), but conclusions were not available at the time. During the 1980's, biologists from federal agencies including the National Park Service (NPS), U.S. Fish and Wildlife Service (USFWS), U.S. Forest Service, and Bureau of Land Management also took part in important studies of wolf ecology, often in cooperation with ADF&G. By the end of the decade, telemetry had been used to study approximately 140 packs for periods of two to eight years in various parts of Alaska, and about 60 packs in the adjacent Yukon (Fig. 1).

In this section we chronologically review scientific research concerning wolf-prey relationships and wolf management conducted in Alaska during 1981–91. Also included are brief descriptions of ongoing research. Other studies that indirectly addressed wolf-prey relationships or management are briefly mentioned.

Advances in ecological knowledge did not diminish the controversy over Alaskan wolf management. As will be discussed later, however, better ecological insight fostered a change in the nature of the debate.

1981

Moose calf mortality studies in the Nelchina Basin indicated that grizzly bears (*Ursus arctos*) were the primary cause of neonatal moose calf mortality (Ballard et al. 1981a), accounting for 79% of the deaths of radio-collared moose calves. Ninety-four percent of the calf mortalities occurred before 19 July each year. Wolves accounted for 3% of the calf mortalities. Although wolves were not an important source of neonatal moose mortality, they were a major cause of winter calf and year-round adult moose mortality (Ballard et al. 1981b).

Holleman and Stephenson (1981) showed that the level of Cesium-137 in wolf skeletal muscle could be useful in assessing prey selection and consumption by wolves. The highest radiocesium concentrations in wolves occurred where caribou or black-tailed deer were available. Prey species that select nonlichen vegetation had lower radiocesium concentrations in skeletal muscle, which were reflected in low levels in wolves preying on them. Radiocesium concentration in wolves has since been widely used in Alaska and northern Canada as an economical way to provide insight into prey selection, especially in areas where both caribou and moose are available.

James (1983) found that two radio-marked wolf packs in northwestern Alaska migrated between summer and winter

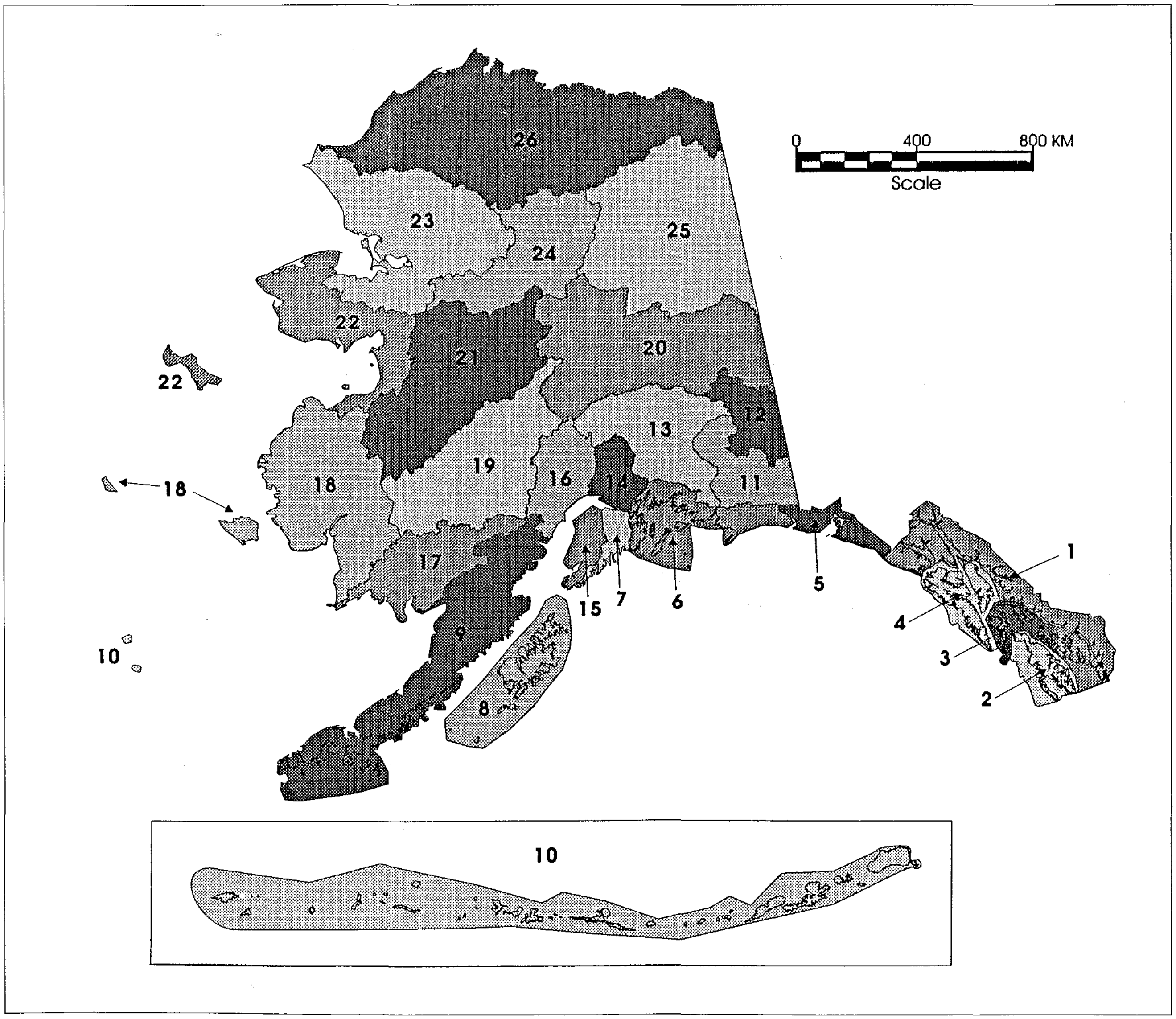

Fig. 2 *Alaska's Game Management Units.*

range in response to migrations of caribou. He found no evidence of selective predation on caribou calves and estimated that during summer wolves preyed on caribou at the rate of 23–38 caribou/wolf/year.

Van Ballenberghe (1981) proposed a revision of all but one of several wolf population estimates made by various investigators in the Nelchina Basin from 1952 through 1978. These estimates later became a focal point in a debate about the effects of wolf predation on caribou (Van Ballenberghe 1985).

1982

Based on the results of an experimental wolf reduction, Ballard and Stephenson (1982) suggested that wolf control measures would be more effective if one to three pack members were radio-collared and left in each pack territory. Advantages of this approach were more reliable information on wolf populations during and after control, continued occupation and defense of territories by radio-collared pack members, and greater efficiency in locating wolves in subsequent population control efforts. Typically, wolf control measures without the above procedures cost $770 to $873 per wolf, and annual removal was necessary to maintain low densities. This study also demonstrated that wolves could quickly repopulate a control area through immigration and reproduction.

Concerns about the taxonomic status of Alaska's wolves led Pedersen (1982) to review the morphological basis for Goldman's (1944) determination that there were four Alaska subspecies. Goldman (1944) based his assessment on 15 skull measurements and recognized the following subspecies: *C. lupus ligoni*, Alexander Archipelago wolf; *C. lupus alces*, Kenai Peninsula wolf; *C. lupus pambasileus*, Interior Alaskan wolf; and *C. lupus tundrarum*, Alaska tundra wolf. Pedersen (1982) reanalyzed Goldman's (1944) data and examined additional skulls using multi-variate statistical tools which had not been available to Goldman. Pedersen concluded that only two subspecies warranted continued recognition; *C. l. pambasileus* and *C. l. ligoni*, the latter occurring in southeast Alaska.

Peterson and Woolington (1982) reviewed the history of wolves on the Kenai Peninsula. Wolves were exterminated by about 1915, largely through the use of poison. They recolonized the area during the 1960's and by 1975 occupied most of the suitable habitat on the peninsula.

Stephenson et al. (1982) evaluated blood sera from 57 wolves for evidence of previous exposure to infectious canine hepatitis virus (ICHV) and canine distemper virus (CDV). Ninety-five percent of the sera were positive for ICHV exposure and 7% were positive for exposure to CDV. The greater incidence of ICHV exposure may have been related to the greater ease of transmission of ICHV or to a higher mortality rate among wolves exposed to CDV. However, the wolf populations studied were generally productive and healthy despite evidence of exposure to these viruses.

1983

Gasaway et al. (1983) studied the interrelationships among wolves, moose, caribou, and man in interior Alaska and reviewed several studies of northern predator-prey systems. They concluded that wolf predation could sustain declines in ungulate populations that were initiated by other factors. Mortality from severe winters, hunting, and wolf predation was largely additive. A 61% reduction in the Tanana Flats wolf population resulted in a two- to four-fold increase in calf and yearling moose survival, respectively. Caribou calf survival also increased significantly, and both moose and caribou populations increased as a result of the wolf reduction program. The study found no evidence of a sensitive, fast-acting feedback mechanism between ungulate and wolf populations. Once ungulate populations reached low levels and were limited by predation, predator reduction appeared to be necessary to allow ungulate populations to escape the effects of predation. The authors showed that prey:wolf ratios can assist in interpreting ecological relationships, but cautioned that predation on young animals often caused survival of young ungulates to be an unreliable indicator of the vegetation-ungulate relationship.

1984

Peterson et al. (1984) studied the ecology of three to seven wolf packs on the Kenai Peninsula during 1976–81. Wolves recolonized the Peninsula in the 1960's after an absence of nearly 50 years. Population density ranged from 11–20 wolves/1,000 km^2. Wolves fed primarily on moose and winter predation rates averaged one moose/pack/4.7 days. Calf moose composed 20% of the early winter moose population but 47% of the wolf-killed moose. Adult moose killed by wolves were relatively old and debilitated. Wolf mortality was largely human caused, averaging 33% annually. Harvests of 30–40% of the early winter population caused declines, and the wolf population was regulated by harvest at the close of the study.

1985

Kellert (1985a) explored American attitudes toward and knowledge of predators, particularly the wolf and coyote (*Canis latrans*), through a national survey. The study showed that Alaskan respondents had the most positive perceptions of the wolf and the greatest knowledge of predatory animals among the various demographic groups studied.

Van Ballenberghe (1985) reviewed the history and dynamics of the Nelchina caribou herd during 1950–81. Based on revised estimates of wolf numbers (Van Ballenberghe 1981), he concluded that severe winters and hunting were the major causes of the herd's decline and that predation by wolves had a minor effect. This manuscript set the stage for further debate on caribou-wolf relationships (Bergerud and Ballard 1988, 1989).

1986

Franzmann and Schwartz (1986) described the importance of black bear predation on moose calves, and compared predation levels in productive and marginal habitats. The level of bear predation was similar (33% vs. 34%) in both habitats. Adams et al. (1989b) initiated a study of wolf ecology in Gates of the Arctic National Park and Preserve in the central Brooks Range. This five-year study focused on population size and distribution, productivity, mortality, seasonal food habits, predation rates, prey selection relative to prey availability, and the effect of annual harvests by man. Eleven to 19 radio-marked packs were monitored annually, more than 2,000 scats were collected from den sites, and more than 100 carcasses of wolves taken by hunters and trappers were necropsied.

The central Brooks Range wolf population was found to be relatively dense (approximately 6.5 wolves/1,000 km^2) and productive, with an average of 47% pups in autumn populations. Yearlings dispersed more frequently than adults, with movements as far as 700 km being documented. Harvest by man and intraspecific strife were major causes of mortality, with harvest being composed of 62% pups and removing about 17% of the park population annually. Caribou, Dall sheep, and moose were common prey for wolves. Intensive monitoring during three seasons showed that the predation rate of packs preying mainly on caribou was nearly stable over a wide range of caribou densities.

Mech et al. (1989) initiated a long-term study of wolf ecology in Denali National Park and Preserve. Preliminary estimates indicated that average wolf density approached 10 wolves/1,000 km^2. Intraspecific strife and trapping along park boundaries appeared to be the major causes of mortality. Wolf numbers more than doubled during the study.

1987

Ballard et al. (1990) initiated a wolf study in northwestern Alaska. Principal objectives included determining the number of wolves within the range of the Western Arctic caribou herd, developing and testing new census methods, and evaluating satellite telemetry for determining movements and territories of wolves. Wolf densities during the first two years of study ranged from 2.7 wolves/1,000 km^2 in spring 1987 to 6.3/1,000 km^2 in autumn 1988. The average life span of seven satellite transmitters was 10 months.

Ballard and Larsen (1987) reviewed knowledge of predator-prey relationships, particularly wolf predation, in relation to moose management. It had become well established that predation by wolves was capable of limiting moose population growth. Moose populations limited by wolves had initially suffered declines due to the combination of severe winters, excessive hunting, and predation. Predation, however, was not a principal cause of most ungulate declines. When moose populations were limited by wolf predation, mortality from predation was additive to other mortality. Moose populations limited by predation apparently could remain at low levels for decades if wolf numbers were not reduced. The possibility of reducing bear density was also discussed. The authors concluded that managers attempting to provide a sustained yield of ungulates would sometimes find predator management necessary where predator populations were naturally regulated.

Ballard et al. (1987) described the ecology of a heavily exploited wolf population in south-central Alaska. Pack territories averaged 1,645 km^2 and did not overlap. Moose were the principal prey and wolves were not migratory. Twenty-eight percent of the dispersing wolves left during April–June and October–November, and 22% of those were accepted into existing packs. Average annual litter sizes ranged from 3.7 to 7.3 pups. Seven to 10% of the packs had two litters per season. When total mortality exceeded 30–40% of autumn numbers, the wolf population declined. Annual finite rates of increase ranged from 0.88 during years of heavy exploitation to 2.4 following termination of population control. Wolf densities during 1975 through spring 1982 ranged from 2.6 to 10.3/1,000 km^2. Seventy percent of observed wolf kills were moose. Wolves preyed on moose calves in proportion to their presence in the moose population during May-October, but killed a disproportionately high number of calves during winter. Kill rates for packs during winter averaged one adult moose/9.3 days, and summer predation rates were similar. Spring wolf densities were negatively correlated with autumn moose calf:cow ratios.

Van Ballenberghe (1987) reviewed the effects of wolf predation on moose numbers and concluded that it was no longer a question of whether controlling effects by predators occurred, but rather under what conditions and how long control lasted. He described two conceptual models (low density equilibria and recurrent fluctuations), which held promise as general theories of predation on moose in naturally regulated ecosystems. Moose were capable of escaping the constraints of predation in the latter, but remained at low densities for long periods in the former model.

Zarnke and Ballard (1987) analyzed blood serum samples from 116 wolves captured in the Nelchina Basin during 1975 through 1982. Rabies, brucellosis, and leptospirosis were rare and had little effect on the wolf population. Exposure to ICHV, canine parvovirus, CDV, tularemia, and Q-fever was relatively common, and these diseases may have negatively affected some individuals in the population.

1988

Boertje et al. (1988) described the extent of predation on moose and caribou by radio-collared grizzly bears in east central Alaska. Adult bears regularly killed adult female moose, especially during spring. Male bears killed moose at a higher rate than did females. The impact of bear predation was estimated to be greatest for low density moose populations. Grizzly bears killed about 4 times more animal biomass than they scavenged. Bergerud and Ballard (1988) compared historical caribou and wolf population fluctuations in the Nelchina Basin and concluded that hunting and wolf predation played an important role in shaping the dynamics of the herd. During years that wolf numbers were low, caribou calf recruitment was high and the population increased. When wolf numbers were high, caribou recruitment was low. Recruitment of 2.5-year-olds from 1952 to 1967 was correlated with wolf numbers. Low recruitment of 3 cohorts during 1964 through 1965, when deep snow caused caribou to calve closer to predators, was a key element in the population decline. There was no evidence of winter starvation. When wolf populations were reduced during the mid-1970's, caribou populations again increased.

1989

Schwartz and Franzmann (1989) explored relationships between bears, wolves, moose, and forest succession on the Kenai Peninsula, concluding that the impact of predation varied with changes in habitat carrying capacity. They concluded that clearly defined management objectives would determine when habitat enhancement or predator control was appropriate.

In an effort to evaluate alternatives to lethal predator control, Boertje of wolves and bears could reduce predation on calf caribou and moose during summer. Results suggested that artificial feeding did not improve caribou calf survival, but may have improved moose calf survival (Boertje et al. 1988).

Gasaway et al. (1990) also investigated alternatives to lethal predator control by determining whether increases in alternate prey, particularly caribou, would reduce wolf predation on moose. Radiocesium concentration was used to assess consumption of caribou by wolves under conditions of high and low caribou numbers (Holleman and Stephenson 1981). As caribou increased in the Delta, Nelchina, and Fortymile herds, consumption of caribou by wolves increased, decreased, and remained constant, respectively. The effect of increased caribou numbers in a wolf-bear-moose-caribou system appeared to be variable and unpredictable (Boertje et al. 1988).

Van Ballenberghe (1989) challenged Bergerud and Ballard's (1988) interpretation of the Nelchina Basin caribou-wolf data, arguing that data on wolf and caribou numbers and caribou recruitment did not warrant statistical analysis because they lacked accuracy and precision. He suggested that when multispecies prey biomass exceeded 200 ungulates per wolf, caribou populations increased. Because multispecies prey biomass consistently exceeded 200 in the Nelchina Basin, he concluded that wolf predation played a minor role in the population dynamics of the Nelchina caribou herd.

Bergerud and Ballard (1989) argued that Van Ballenberghe's (1985) principal reason for discounting the importance of wolf predation was that wolf numbers were low and stable from 1962 to 1974. They pointed out that Van Ballenberghe (1981) had revised nine of 10 wolf population estimates. Original estimates indicated that wolf numbers increased at an annual finite rate of 1.30, which was close to the average of other wolf populations in North America, and were negatively correlated with caribou recruitment. Historically, caribou recruitment improved three times following reductions in wolf numbers. Bergerud and Ballard (1989) concluded that the decline of the herd from 1962 through 1972 could be explained by excessive human harvest combined with poor recruitment.

1990

Based on a study of predator-prey relationships in east-central Alaska, Gasaway et al. (1992) concluded that high-density moose populations in Alaska were generally the result of predator management. Where both wolves and grizzly bears were exploited by humans at moderate to high levels, moose appeared to stabilize at moderate densities. In areas where two to three large predator species were naturally regulated, moose populations existed at low-density equilibria (Gasaway et al. 1992). The authors concluded that in northern systems moose will not escape low levels without predator management.

1991

The history of the Nelchina Basin moose population was reviewed, and the effects of wolf predation on moose were intensively studied from 1976 through 1986 by Ballard et al. (1991a). Wolf predation did not cause a moose population decline in the late 1960's and early 1970's, but did appear to accelerate it. Population modeling indicated that if wolf populations had not been reduced during the 1970's, moose recruitment would have remained low and the moose population might have continued to decline. A combination of mild winters, reduced predator numbers, and restricted harvests allowed the moose population to increase 3–6% annually from 1976 through 1985 (Ballard et al. 1986, 1991a).

In addition to research pertaining directly to wolf-prey relationships and wolf management, numerous other studies were published during the decade. The range of topics included various aspects of life history (Ballard 1982, Eide and Ballard 1982, Stephenson and James 1982, Ballard et al. 1983, Ballard and Dau 1983), capture techniques (Ballard et al. 1982, 1991b, Tobey and Ballard 1985), cementum aging techniques (Goodwin and Ballard 1985), wolf census techniques (Becker and Gardner 1990), and a comparison of the knowledge of wolves possessed by Nunamiut Eskimos and western scientists and the methods used in developing it (Stephenson 1982).

1992

The research completed in 1990 and first presented in an ADF&G final report (Gasaway et al. 1990a) was published in 1992 as a wildlife monograph (Gasaway et al. 1992). The Wildlife Society recognized the work as the best wildlife monograph of 1992. A study of wolf productivity in Interior

Alaska concluded that productivity of wolf populations declined after prey availablity reached extremely low levels (Boertje and Stephenson 1992), with high reproductive potential occurring at ungulate densities found in most parts of North America.

The conclusions of other important studies became available in 1992 and are represented in this volume. These include the results of a major study of wolf-prey relationships in Denali National park addressing prey selection (Mech et al. this volume), predation on caribou calves (Adams et al. this volume), and pack structure and genetic relatedness (Meier et al. this volume). Winter predation by wolves was studied in Gates National park (Dale et al. this volume). Boertje et al. (this volume) concluded an evaluation of several lethal and nonlethal methods of reducing predation on moose. A study of the effectiveness of satellite radiocollars in tracking wolf movements was completed, as were studies of techniques for surveying and aging wolves (Ballard et al. this volume). Klein (this volume) reviewed the results of the experimental introduction of wolves to Coronation Island in Southeast Alaska.

Research Needs

The results of some wolf control programs indicate that wolf predation on moose neonates can be a major mortality factor (Gasaway et al. 1983). However, results of moose calf mortality studies in other areas suggest that wolves only account for about 17% of early summer moose calf mortality (Ballard 1992), with bear predation being the major source of mortality. Accurately assessing the effects of bear and wolf predation, both separately and combined, in northern systems continues to be a challenge, with bear predation the most difficult to assess. Improving our ability to estimate bear populations and the effects of bear predation on moose and caribou would allow better assessments of the cost, benefits, and advisability of predation control in specific situations.

The nature of the functional responses through which wolves persist at low prey densities are poorly understood and deserve more study. Long-term studies of wolves are necessary to help predict functional and numerical responses of wolves to changes in prey.

Although some investigators (James 1983, Ballard et al. 1987) have found that summer and winter food habits and predation rates are similar, a number of questions remain. Relatively little is known about nutritional condition or sex and age composition of prey killed by wolves during summer. Whether scats collected at dens and rendezvous sites accurately represent food habits is unknown, as is the accuracy of scat analyses. The conditions in which wolves cause significant neonate mortality are unknown These and many other questions concerning wolf life history during summer constitute a knowledge deficiency about northern wolves.

Wolf Management in Alaska, 1981–91

Although research helped resolve a number of biological and management questions, in some cases contradictory findings or attempts to reevaluate historical data seemed to fuel both scientific and public debate. Wildlife managers acknowledged that human values and ethical judgments about the treatment of wildlife populations or individual animals were at the heart of the controversy.

Harbo and Dean (1983) indicated that all the major legal issues surrounding state-conducted wolf control programs had been settled by the 5 February 1980 ruling of the U.S. Court of Appeals for the DC Circuit. In a case brought by Defenders of Wildlife and other plaintiffs, the court ruled that state aerial wolf control could proceed in Alaska on federal land without an environmental impact statement (EIS). In addition, it affirmed the state's authority over resident non-endangered wildlife and thereby lifted all legal prohibitions against wolf control conducted by ADF&G. Legal challenges during the 1980's also had only temporary effects. However, wolf management continued to be dominated by political obstacles and debate which maintained the costly stalemate through the end of the decade.

In February 1980 the Alaska Board of Game (Board) had approved five of seven areas recommended for aerial wolf hunts to reduce predation on moose. GMU's 19A, 19B, 20A, and 21 had been reapproved; GMU's 20B, 20C, and 20D were added; and GMU 20E was not approved because of pending federal land withdrawals in the vicinity of the Yukon and Charley rivers. Permits were issued to private hunters to hunt wolves from fixed-wing aircraft. Because of poor hunting conditions during spring 1980, only 53 wolves were killed, half of them by ADF&G personnel.

Later that spring, ADF&G presented a draft revision of its 1973 wolf management policy to the Board for review. This policy detailed ADF&G's basic philosophy and approach to wolf management, including the application of wolf control. After limited public and agency review, these policies were finalized and published in December 1980.

The following is a chronological review of major events, issues, and decisions affecting wolf management since 1980.

1981

During winter 1980-81, wolf control continued in six GMU's and a total of 113 wolves were taken by ADF&G and private aerial hunters. In April 1981, the Board adopted Policy #81-28-GB, "Letter of Intent Regarding Wolf Reduction in Alaska," that stated that the primary purpose of wolf reduction was to rehabilitate and restore depressed ungulate populations.

In September, ADF&G recommended continued aerial shooting of wolves in the five previously-approved GMU's, as well as in GMU's 20E and northern GMU 12. To achieve a 60–80% reduction of wolves in specific parts of these GMU's, ADF&G recommended that fixed-wing and helicopter aircraft be used. These proposals were reviewed by the Board in November 1981.

1982

In February the director of the Division of Wildlife Conservation and the commissioner of ADF&G approved the new programs in GMU's 12 and 20E. The total number of wolves killed in control programs during 1981–82 was 85. At their December 1982 meeting, the Board again reviewed ADF&G's wolf management policies and plans for wolf control programs. Although a public hearing on the policies and plans was held, public comment was limited because the plan was distributed on the afternoon of the hearing and only written comments were accepted.

The following day the Board adopted ADF&G's "Wolf Management Policy" with a "Supplement on Wolf Population Control" as Board policy. This action set the stage for the next legal challenge to implementation of wolf control in Alaska.

Following the December Board meeting, the Alaska Wildlife Alliance (Alliance) filed complaints with the State Ombudsman Office (Ombudsman) claiming that ADF&G did not allow sufficient public input into its wolf control program and was unresponsive to requests for information. The Alliance also questioned ADF&G's authority to issue an aerial wolf hunting permit to the Reindeer Herders Association in GMU 22 on the Seward Peninsula without public notice or input.

1983

At the March Board meeting, the Ombudsman reported that, in its opinion, the wolf management policy adopted by the Board was a regulation and the Board should not bypass the regulatory process by calling it a policy. The Ombudsman further stated that wolf control policies adopted by the Board to date were invalid because they were intended to have the effect of regulations, but were not adopted according to rules established by the Administrative Procedures Act (APA). The APA, among other things, requires public notice and provision for public comments on any proposed regulations. The Ombudsman indicated that ADF&G could not legally conduct a wolf control program in the absence of regulations promulgated by the Board.

As a result of the Ombudsman's opinion, the Board recommended a full public review of wolf management and control programs at its December 1983 meeting. The Alliance asked the Board and ADF&G to suspend wolf control until the public review was completed and new regulations were adopted. ADF&G declined this request and resumed control efforts in late October 1983.

On 2 November 1983, the Alliance filed a complaint against the state in Alaska Superior Court challenging the authority of ADF&G to conduct any predator control programs in the absence of regulations developed by the Board through the public process required by the Alaska APA. A temporary restraining order was issued on 4 November 1983 prohibiting ADF&G from aerial shooting after nine wolves had been killed. On 14 December 1983, Alaska Superior Court Judge Shortell granted the preliminary injunction sought by the Alliance. However, ADF&G was allowed to proceed with preparatory efforts, such as the radio-collaring of wolves.

ADF&G and the Board requested the Alliance postpone any further legal proceedings until after the March 1984 meeting to allow the state to meet APA requirements. The Alliance agreed to this because the preliminary injunction prevented any resumption of aerial wolf hunting until March.

1984

At the March meeting, the Board considered hunting and trapping regulations and policy proposals in addition to aerial wolf hunting and predator control issues. Many state Fish and Game Advisory Committees favored maintaining wolf control as a management tool. Most opposing testimony came from private individuals, organizations such as the Alliance and Defenders of Wildlife, and non-Alaskans. The Alliance submitted a proposal to replace the "Wolf Management Policy" with a regulation that defined predator control as an emergency measure, which should be limited to specific situations, rather than being considered as a standard management tool.

On the advice of the Alaska Department of Law, the Board adopted a proposal placing wolf control under regulatory requirements for public review before authorization. This new regulation required all control programs to be based on scientific evidence and consider both consumptive and nonconsumptive users of wildlife. Regulations were required to identify population objectives for both wolves and prey. This caused wolf control to be viewed primarily in relation to long-term management objectives, instead of as isolated programs. In addition, programs had to be reviewed and reauthorized after three years, and both denning and poisoning continued to be prohibited. Wolf control on federal lands required the consent of the appropriate federal land managers. As a result of the Board's adoption of this regulation, the Alliance lawsuit was dismissed by joint agreement and the injunction against wolf control was lifted.

In August, the Board held public hearings in Delta Junction and Fairbanks as ADF&G proposed renewing wolf control in GMU's 12, 20A, 20B, 20D, 20E, and possibly adding 25D. The Board also received four wolf control proposals from local Fish and Game Advisory Committees.

In September, acting under the new regulations, the Board voted to reauthorize aerial shooting of wolves, now called wolf predation control, in GMU's 20A and 20B beginning 1 November. No public aerial hunting permits were to be issued. All control was to be done by ADF&G, and the Board authorized the use of radiotelemetry and helicopters to locate wolves to increase efficiency of control.

The Board postponed a decision on GMU's 20D, 20E, and part of 12 until the December meeting.

In December, the Board held a public meeting in Anchorage at which the majority of the testimony was opposed to aerial wolf control. Nevertheless, the Board voted to authorize aerial wolf hunting in adjacent parts of GMU's 12 and 20E. ADF&G's plan called for killing 100 of the 125 wolves in a 13,000-km^2 area. The Board rejected a proposal for an aerial wolf hunt in the McGrath area.

Although ADF&G moved to implement these programs, on 27 December 1984 the Federal Communications Commission (FCC) sent a letter to the State of Alaska ordering ADF&G to stop using radiotelemetry to locate wolves during authorized control programs. The FCC claimed that such use violated the license granted to ADF&G for the use of radio transmitters in research. However, a review of the license stipulations found that some frequencies could legally be used for this purpose.

1985

The controversy over wolf control spread beyond ADF&G and the Board and entered the legislative arena in January. At that time, five "bills" or "resolutions" regarding wolf management were introduced into the Alaska Legislature: SB 62 to prohibit aerial wolf hunting, HCR 15 regarding the harmful effects of wolves, SB 241 calling for a $250 bounty on wolves, and companion bills HB 397 and SB 298 that would take the authority to make decisions on wolf control programs away from the Board and the statewide public process and transfer it to ADF&G and the local Fish and Game Advisory Committees with no requirement for public review. Although none of these initiatives reached a final vote in the legislature, heated debate occurred in committee sessions.

In early 1985, Board chairwoman Johnson wrote to the Commissioner of Fish and Game requesting that ADF&G not implement the aerial wolf hunts approved by the Board in September and December 1984. She also requested that all previously authorized aerial wolf hunts be proposed again for reconsideration by the Board at their March–April meeting, and that ADF&G be prepared to discuss alternatives to current wolf control programs at that time. In February, ADF&G initiated a review of their approach to wolf management. It had become apparent that the public should be more deeply involved in the decision-making process regarding both policies and regulations. These ideas were considered in light of contemporary approaches to conflict resolution, consensus building, and citizen participation (Haggstrom et al., this volume).

During the spring meeting, the Board considered five new proposals for aerial wolf hunts in addition to three programs authorized in 1984. The Board voted not to approve new control programs and repealed the previously authorized programs in GMU's 12, 20A, and 20E, leaving only the GMU 20B program in effect.

The Board also requested that ADF&G prepare an analysis and report for the autumn Board meeting to reassess the existing program in GMU 20B and to further develop possible alternatives to aerial hunting. A report, entitled *An Assessment of Wolf Predation Control Alternatives for Portions of Interior Alaska*, was presented to the Board in November 1985. At this meeting the Board reauthorized the previous regulations regarding wolf control programs, including continuation of wolf control in GMU 20B. Following the Board's authorization, employees of ADF&G used fixed-wing aircraft, helicopters, and radiotelemetry to reduce the wolf population in the Minto Flats area near Fairbanks. By late winter, 34 wolves had been killed, 29 of them by aerial shooters. Although the GMU 20B wolf control program was authorized through 1990, no aerial shooting occurred after March 1986. Population monitoring indicated that wolf numbers had been reduced sufficiently to achieve the desired increase in moose numbers.

One alternative to aerial wolf control that ADF&G identified was trapper education and assistance. After debating whether these were a form of wolf control, the Board authorized trapper education programs for GMU's 19D and 25D. Neither program resulted in any increase in wolf harvest. However, because the Board had authorized control in a large part of the Yukon Flats National Wildlife Refuge, Defenders of Wildlife threatened a lawsuit if an EIS was not prepared. The USFWS considered preparing an EIS, but in December 1985 the USFWS wrote ADF&G reaffirming their policy, based on prior court rulings that neither was necessary, and they concurred with the proposed trapper education program. No litigation was initiated.

While the Board's adoption of regulations governing wolf control seemed to resolve the legal obstacles to officially sanctioned programs, a related controversy developed over state trapping regulations that allowed a person to fly in an airplane to locate wolves, then land and attempt to shoot them. This practice came to be known as land-and-shoot taking. The official term, same-day-airborne, is sometimes used interchangeably.

Two concerns were expressed. First, many people believed that aircraft were being used to drive wolves into the open and that in some cases people shot from the air before landing. Either action would be a violation of both the Federal Airborne Hunting Act and state regulations. Second, because land-and-shoot taking was an effective method for killing wolves in open areas, it was believed that this practice was, in fact, wolf control. This view eventually led to legal action.

1986

In July the Alliance, Greenpeace USA, and four individuals filed a lawsuit against the state in Alaska Superior Court in Anchorage. The plaintiffs claimed that land-and-shoot trapping was a method of wolf control and should therefore be subject to the procedures and standards set forth in the

Alaska Administrative Code. The suit further alleged that ADF&G was using land-and-shoot trapping as a means to evade the wolf predation control regulations, and it requested the Board to hold public hearings to develop an implementation plan for the land-and-shoot method for each GMU. It also asked that this method be prohibited statewide except in areas where wolf predation had caused moose and caribou populations to be severely depressed.

1987

After hearing oral arguments in January, Alaska Superior Court Judge Ripley signed a Summary Judgment in favor of the state which read in part: "This court finds that the Board of Game's regulations that allow a trapper to take wolves the same day the trapper has been airborne...is reasonably necessary to carry out the board's authorities to regulate methods and means of harvest..., that the regulations are not arbitrary and capricious, and that they do not constitute an authorized program for wolf control."

The Alliance and other plaintiffs filed an appeal to the Alaska Supreme Court in February maintaining their allegation that the Board's regulations allowing aerial trapping constituted an unauthorized program for wolf control. In December, the Alaska Supreme Court decided against the plaintiffs and affirmed the Superior Court decision that land-and-shoot trapping was not a form of wolf control and was therefore not subject to the administrative regulations governing wolf control programs.

While litigation over land-and-shoot trapping proceeded, the Board met again in November 1987 to discuss wolf hunting and trapping regulations. After public hearings in Fairbanks and Anchorage, the Board voted to place further restrictions on land-and-shoot taking. This was accomplished by classifying this method as hunting rather than trapping and authorizing it only in GMU's 9, 17, 19, 21, 23, 24, and most of 25 with a bag limit of 10 wolves. Although these changes reduced wolf harvests to some degree, they did little to resolve the controversy between supporters and opponents of the method. Placing land-and-shoot in hunting regulations also led to a confrontation between the state and the NPS regarding wolf hunting in national preserves.

The NPS held that land-and-shoot hunting was not a fair chase method of taking wolves. As such, it was in conflict with NPS policies governing hunting in preserves. NPS had previously prohibited land-and-shoot trapping by refusing to recognize firearms as a legal method of trapping. As a result of the Board's actions, NPS initiated development of federal and state regulations to close preserves to land-and-shoot hunting.

1988

In September, the NPS submitted a regulation proposal to the Board requesting the closure of eight national preserves to land-and-shoot hunting of wolves. The Board returned the proposal because their schedule did not provide for the discussion of wolf regulations until the following year. Because there was no biological problem caused by the hunting, the Board also refused to consider the ban on an emergency basis.

The NPS held hearings in October on their proposed regulation and public opinion was strongly in favor of the ban; in November they enacted a temporary one-year ban on land-and-shoot hunting of wolves in eight preserves. The state objected to the NPS regulation, claiming it was not necessary and usurped state management authority. Wolf regulations were not on the agenda for the autumn 1988 Board meeting, so the NPS asked the Board to agree to consider a proposal at its March 1989 meeting to permanently ban land-and-shoot hunting in the preserves. Because there was no biological justification for the temporary ban the NPS already had in place and was working to make permanent, the Board decided not to discuss the issue at this meeting.

1989

The NPS published a proposal in the 9 June *Federal Register* to adopt a permanent ban on land-and-shoot hunting of wolves on the national preserves in Alaska. In August, the NPS resubmitted their proposal to the Board to close national preserves to land-and-shoot hunting. Informal discussions between NPS and ADF&G indicated that if the Board adopted the proposal, NPS would halt development of the federal regulation.

At their November meeting, the Board discussed wolf regulation proposals. ADF&G recommended that land-and-shoot hunting be authorized only where it provided some management benefit and supported the NPS proposal to close the preserves. Despite ADF&G recommendations, the Board expanded land-and-shoot hunting by adding four GMU's to the seven in which it was already legal, and deleting one. However, the Board imposed additional conditions requiring all hunters to obtain a permit from ADF&G before hunting, limiting hunters to no more than three GMU's at any given time, and requiring hunters to immediately tag wolves they killed. The Board also voted to adopt the NPS proposal resulting in NPS postponement of its move to establish a permanent ban.

At this Board meeting, ADF&G proposed the development of a strategic wolf management plan for Alaska, emphasizing public involvement. ADF&G recommended appointing 10 or 12 citizens, representing a diversity of interests, to a Wolf Management Planning Team. Public forums and other means to involve the public in guiding wolf management were also suggested. The Board endorsed this proposal, and, as a result, took no action on seven proposals for wolf control programs nor on proposals to revise the state's guidelines for wolf management programs.

The Future of Wolves in Alaska

Until recently, ADF&G was solely responsible for wolf management in Alaska. However, in December 1989, the Alaska Supreme Court ruled that elements of the state's subsistence law, which gave preference to rural Alaskans in the allocation of wildlife, violated the State Constitution. Under provisions of the Alaska National Interest Lands Conservation Act of 1980, the federal government was therefore required to take over management of subsistence hunting and trapping on federal lands and provide the rural preference mandated by the U.S. Congress. This resulted in a dual management system on federal land, which comprises about two-thirds of the state. The implications for management of wolves are not clear at this time.

The outlook for the continued existence of a large wolf population in Alaska is good, and it is ADF&G's policy to maintain viable wolf populations in all parts of the wolf's historic range. There is broad public support in Alaska and elsewhere for maintaining an extensive population of wolves in the state. However, to many Alaskans, maintaining or enhancing game populations through regulation or periodic reduction of wolf populations is valid and necessary. To others, and to many people outside Alaska, such management is viewed as extreme and unethical and a continuation of the pattern of events that exterminated the wolf in parts of its historic range.

Predation by wolves and bears often plays an important role in maintaining ungulates at low densities. Consequently, local residents, to whom the quantity of wildlife is important, and ADF&G, operating under its constitutional and statutory mandates, will periodically find it necessary to propose regulating or temporarily reducing a local wolf population in order to maintain ungulate numbers near levels that habitat can support. Although recent control programs have involved a maximum of three percent of Alaska's land area, they continue to place Alaska's wildlife management at odds with the convictions of a large number of people who currently view the manipulation of wolf populations as undesirable and as a threat to wolf conservation.

The effects of bear predation on ungulate populations will continue to confound the issue of wolf management (Hayes et al. 1991) in areas such as Alaska and the Yukon, where bears and wolves often coexist at high densities. Research has shown that predation by bears can slow the recovery of ungulate populations even when wolf numbers are dramatically reduced. The management of bear populations and predation poses special problems in addition to those inherent in wolf management due to differences in public perception and population biology. The risk of long-term effects resulting from high harvests is greater for bears because of their lower productivity.

Despite the conflicts inherent in the relationship of people to large predators and prey, we should not lose sight of the fact that wolf and bear populations are extensive in Alaska and adjacent regions and have generally expanded in recent years. Both official policy and public opinion are clearly supportive of maintaining these populations, and the outlook for their continued coexistence with people is good.

The recent history of wolf-human relationships suggests that some level of controversy inevitably accompanies success in wolf conservation. In many respects the management of large predators, such as wolves, is a lightning rod for attitudes toward the environment. The fact that people with different values care deeply enough about wolves and wild country to express their concerns should be cause for optimism.

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Ecology and Conservation of

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