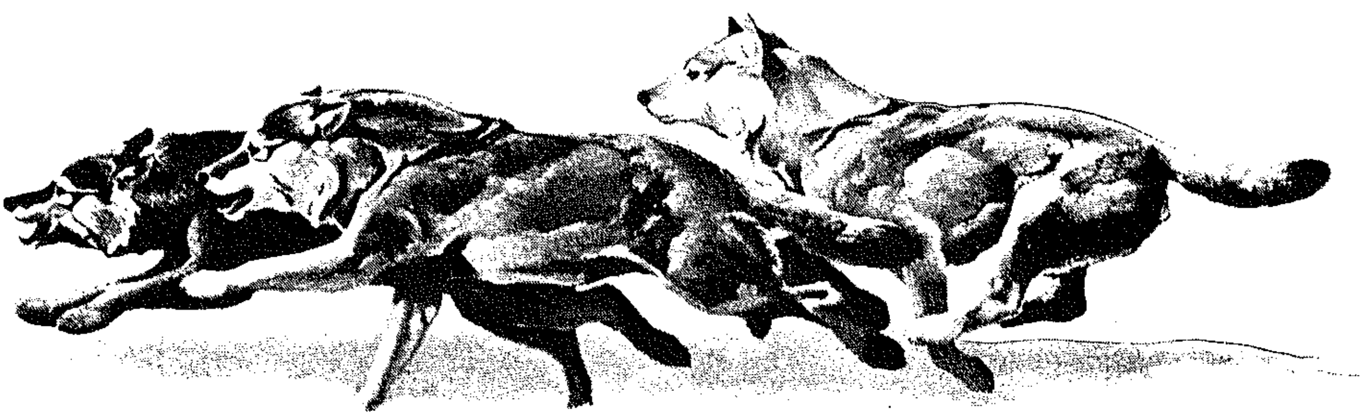
RESTORATION OF WOLVES IN NORTH AMERICA



THE WILDLIFE SOCIETY

Technical Review 91-1

February 1991

Restoration of Wolves in North America

The Wildlife Society

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Technical Review 91-1
February 1991

Foreword

Presidents of The Wildlife Society occasionally appoint ad hoc committees to study and report on selected conservation issues. This has worked reasonably well, but experience indicated a need to standardize the procedures. On advice from the Publications Committee in 1989, the Society's governing Council agreed to refine its oversight role, to appoint an editor or editors to assist the committees, and to establish standard formats for the committee reports.

The reports ordinarily appear in 2 related series called either Technical Review (formerly "White Paper") or Position Statement. The review papers present technical information and the views of the appointed committee members, but not necessarily the views of their employers or The Wildlife Society. Position statements are based on the review papers, and the preliminary versions ordinarily are published in **The Wildlifer** for comment by Society members. Following the comment period, revision, and Council's approval, the statements are published as official positions of The Wildlife Society.

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This report may be cited as: Peek, J. M. et al. 1991. Restoration of wolves in North America. Wildl. Soc. Tech. Rev. 91-1. 21pp.

Acknowledgments

We thank the following people for reviewing this manuscript: R. G. Anthony, E. E. Bangs, J. C. Bednarz, N. S. Bishop, C. E. Braun, W. Brewster, L. N. Carbyn, R. L. Crabtree, B. L. Cypher, R. A. Demarchi, A. Dood, T. France, S. H. Fritts, H. E. Hodgdon, K. Horn, R. J. Mackie, J. E. Miller, D. G. Miquelle, J. O'Laughlin, W. T. Parker, R. O. Peterson, M. K. Phillips, D. H. Pletscher, B. A. Rattner, R. R. Ream, G. H. Savage, F. J. Singer, P. A. Tucker, J. D. Varley, J. S. Whitman, and J. J. Yeo. We appreciate the excellent typing assistance provided by S. K. Roach on numerous drafts of this paper.

Cover art, logo of the International Wolf Center, generously provided by the Center, Ely, Minnesota, from the painting "Wolf Pack" by F. L. Jaques and owned by Mr. Donald Duncan.

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SYNOPSIS

Restoration of gray wolves (*Canis lupus*) and red wolves (*C. rufus*) to parts of their former ranges in the contiguous 48 states is in progress. Concern over effects of these restorations on livestock and other wildlife species is evident. Methods of restoration, management of restored populations, and perceptions and support for restoration are of concern.

The taxonomy of the gray wolf needs to be revised to determine the validity of the 24 subspecies. However, consideration of subspecies in assessing restoration of wolves to the designated recovery areas in the Northern Rocky Mountains is unnecessary if the source of wolves is from adjacent regions in Canada. The red wolf currently is considered to be a distinct species. Both species are highly social and occur in packs of 2 to >25 animals. New packs are formed by dispersing individuals that locate mates. Packs defend territories and maintain them by howling and scent marking. Lone, unmated wolves scent-mark rarely, whereas newly formed pairs scent-mark frequently. The occurrence of individual wolves outside the current breeding range is expected because dispersing individuals have been known to move over 700 km from their former home ranges. Recolonizing activities must involve mated pairs that reproduce and form packs, rather than isolated individuals.

Gray wolves currently inhabit the Lake Superior region, the northern Rocky Mountain region, and may be recolonizing northern Washington. The Minnesota wolf population is an extension of the Ontario population. Wolves have been colonizing Wisconsin since 1975 and may be colonizing Michigan. Since recolonization, the Isle Royale National Park wolf population currently is at an all-time low. Wolves are recolonizing in the Flathead River drainage in western Montana. All wolves in the contiguous 48 states are classified as endangered, except the Minnesota population, which is classified as threatened.

In Canada, 40,000-50,000 gray wolves occur in about 80% of their former range. In Alaska, 5,200-6,500 wolves occur on most of their original range on about 84% of the state's land area. Wolves generally are classified as big game and furbearers in Canada and Alaska.

Mexican wolves (*C. l. baileyi*) may occur in the wild in only 3 areas in Mexico, but have not been observed in the United States since 1975. Red wolves have been reintroduced in eastern North Carolina, South Carolina, and Mississippi, and plans to restore them to Great Smoky Mountains National Park and other areas are underway.

Estimates of wolf populations necessary for maintaining genetic variability and for avoiding inbreeding depression provide general guidelines. Detailed monitoring of reintroduced populations and isolated populations such as the one on Isle Royale will be needed to improve the estimates of minimum breeding populations.

The need to involve and inform the public about plans and progress in wolf restoration is critical. Enmity towards these species exists along with strong support. Public education must be factual and objective about wolves, exposing the myths and addressing the negative aspects of wolf relations with humans.

Reintroductions of wolves should occur in areas with an adequate prey base, sufficient size, and low levels of human activity. Retaining wolves less than 1-year-old in holding pens for up to 6 months and providing carcasses of prey that are of the intended prey species may be the most successful technique of restoring wolves.

Management of restored wolf populations requires substantial planning. Wolves in national parks or refuges where hunting is prohibited will pose fewer problems than wolves in areas used by livestock or where their prey base is hunted. Close coordination with interest groups whose activities are affected by the presence of wolves must be maintained for restoration to be successful.

INTRODUCTION

Restoring gray wolves and red wolves to parts of their former ranges is an important part of recovery plans for these species. Red wolves have been restored to parts of North and South Carolina and Mississippi (Parker 1988, Phillips and Parker 1988). An attempt to restore eastern timber wolves (*C. l. lycaon*) in Michigan failed (Weise et al. 1975). Restorations of the northern Rocky Mountain wolf (*C. l. irremotus*) and the Mexican wolf have been proposed (U.S. Fish and Wildlife Service 1982, 1987*b*).

Concern over the effects of restoring wolf populations has increased as recovery plans have become more widely known. Hunters and livestock owners are concerned about the effects of these predators on game and livestock (Miniclier 1987). State wildlife agencies are concerned over federal intervention in state wildlife issues and question whether public pressures and lack of funds will preclude effective management (Aderhold 1987). Wildlife agencies involved in restoration lack credibility among some groups which further hampers introduction efforts.

Methods for restoration, management of restored populations, and perceptions and degree of support by all people involved largely will determine the success of recovery efforts for these species. We review in several contexts the status of wolves in North America, sociological implications of restoration, methods of establishing populations, recovery goals, and management. This review is provided for development of a position statement on wolf restoration by The Wildlife Society.

TAXONOMY

Wolves have been divided into 2 species: gray and Mexican wolves (*C. lupus*) and red wolves (*C. rufus*). Twenty-four subspecies of the gray wolf have been reported in North America (Hall and Kelson 1959, Mech 1970). But distinctions among most subspecies are rather fine, and several have been described on the basis of only one or a few specimens (Goldman 1944, Mech 1970). Furthermore, only 8 subspecies are recognized in Europe and Asia (Mech 1970). Records of gray wolves dispersing 700 km or more from their home ranges (Fritts 1983, Ballard et al. 1987) suggest fewer valid subspecies of wolves than have been recognized in North America. Thus Nowak (1983) recommended a thorough revision of North American gray wolf taxonomy and suggested the existence of as few as 5 valid subspecies.

The probable lack of validity of most North American wolf subspecies is of special interest to the proposed restoration of wolves in Yellowstone National Park. The indigenous and questionable subspecies is the northern Rocky Mountain wolf. However, immediately north of this subspecies' range are populations of wolves (*C. l. columbianus*) that are sufficiently similar to *C. l. irremotus* in food habits and habitat occupied to be used for restoration to the park. The more northerly subspecies currently is colonizing the former range of *C. l. irremotus*. Consideration of subspecies in assessing whether wolves should be restored to the Yellowstone area is unnecessary, but the transplant stock should come from populations in nearby Canada or the colonizing population near Glacier National Park.

Nowak (1979) and Atkins and Dillon (1971) consider the red wolf to be a distinct species, although others (Lawrence and Bossert 1967, Mech 1970) disagree. The red wolf historically occupied one of the smallest ranges of all canids and certainly the smallest of any *Canis*, except possibly the Abyssinian wolf (*C. simensis*). Three subspecies of red wolf are recognized: *C. r. floridanus* (now extinct), *C. r. gregoryi*, and *C. r. rufus* (Goldman 1937).

STATUS OF WOLVES IN NORTH AMERICA

Gray Wolf: Contiguous 48 States

All wolves in the contiguous 48 states are classified as endangered, except the Minnesota population, which is classified as threatened.

Gray wolves currently inhabit 2 regions of the 48 contiguous states: the Lake Superior region and the northern Rocky Mountain region. Additionally, a wolf den with pups was located in summer 1990 in North Cascades National Park, Washington, suggesting that natural recolonization is imminent.

In the Lake Superior region, the main population of 1,200 wolves occupies an area of about 59,900 km^2 in Minnesota just south of Ontario (Mech et al. 1988). Thus, the Minnesota wolf population can be considered the southern extension of the Ontario wolf population; some packs range on both sides of the border and lone dispersers travel between the 2 countries (Mech 1987). In Minnesota, individual wolves may be killed by government controllers of livestock depredation in about 66% of the wolf's range (U.S. Fish and Wildlife Service 1987*a*).

Since about 1975, wolves from Minnesota have been colonizing Wisconsin (Mech and Nowak 1981, Thiel and Welch 1981) where they number about 30 (Thiel 1985). The population is increasing slowly, but growth has been hindered by human-caused mortality, dispersal back to Minnesota, and possibly canine parvovirus (CPV).

Only 6-10 wolves are now in mainland Michigan where human-caused mortality frequently removes wolves (Weise et al. 1975, Robinson and Smith 1977). An intermittent influx of loners from Wisconsin and Ontario seems to be sufficient to maintain this small population.

Since recolonization on Isle Royale in Lake Superior, the wolf population is at an all-time low of 11-14 animals (Peterson 1989, and pers. commun.). Possible causes of the population decline include lack of vulnerable prey, CPV or Lyme's disease, and inbreeding.

In the northern Rocky Mountain region, wolves were protected by the states of Montana in 1975 and Idaho in 1977 (U.S. Fish and Wildlife Service 1987*b*). In Wyoming they still are classified as predators. Wolves have been recolonizing in the North Fork of the Flathead River area in western Glacier National Park since 1979 (Ream and Mattson 1982), and in summer 1989, 3 packs totaling at least 16 wolves were in that area and adjacent southern British Columbia (R. R. Ream, Univ. Montana, pers. commun.). The population is protected in the United States, but is subject to illegal killing, control of depredating animals, and legal harvest in British Columbia. Another pack of wolves formerly inhabited the Blackfeet Indian Reservation just east of Glacier National Park. This pack preyed on livestock and all but 1 wolf was removed in 1987. A pack inhabiting Flathead County west of Kalispell was trapped in 1989 and removed to prevent livestock depredations. Only 1 member is known to have survived.

Wolves were indigenous to the Yellowstone region; radiocarbon dating of a bone from a cave in Yellowstone National Park showed wolf habitation of as long as 960 years ago (Hadly 1989). No resident wolf packs were present in the Yellowstone region after the 1930s, although reports of single wolves or pairs persist (Weaver 1978). Nine possible occurrences of wolves were recorded during 1980-86, all of which are considered transients (M. Meagher, Summary of possible wolf observations 1977-1986, report on file, Yellowstone National Park, Mammoth, Wyo., 1987). Such activity has been recorded since 1930, but no established, breeding pairs or pack activity have been documented (Weaver 1978).

Estimates of 6-15 wolves were made for the central Idaho wilderness areas (Kaminski and Hansen 1984). However, there has been no authenticated sign of pair formation or reproduction.

Gray Wolf: Canada

An estimated 40,000-50,000 gray wolves, about 90% of the North American wolf population, are in about 80% of their former range in Canada (Carbyn 1987). Wolves have been extinct in New Brunswick, Prince Edward

Island, and Nova Scotia since 1870 and in insular Newfoundland since 1911 (Carbyn 1987). The remaining 6 provinces and 2 territories currently support wolf populations in most suitable habitats. An estimated 13,000 wolves inhabit British Columbia and Alberta, which are adjacent to areas of potential wolf restoration in the western United States.

Legal status and hunting/trapping regulations for wolves in Canada are highly variable. Some jurisdictions (e.g. Northwest Territories, British Columbia, and Manitoba) classify wolves as both big game and furbearers. Others (e.g. Saskatchewan, Labrador, and Ontario) classify them as furbearers only. In Alberta, wolves are classified as a furbearing carnivore.

Open seasons range from year-round (Ontario) to 10 weeks in Manitoba (Carbyn 1987), but most jurisdictions have a long season with liberal or unrestricted bag limits. Management units in southern British Columbia are either closed, have short open seasons, or restricted harvest quotas in deference to wolf recovery efforts in the United States. Documented wolf harvests throughout Canada have ranged from 3,000 to 4,000 annually in recent years. However, wolf harvests in local areas may be high; e.g. about 900 wolves were taken by villagers using snowmobiles in winter 1978-79 near Coppermine, Northwest Territories.

In recent years, about 300 wolves have been taken annually to protect livestock in 6 Canadian jurisdictions. Three provinces permit the use of strychnine and one uses 1080 (monosodium fluoroacetate). The remainder encourage trapping and hunting to deal with livestock depredations. Yukon Territory, British Columbia, and Ontario currently conduct wolf control to increase ungulate populations in local areas. British Columbia removed 996 wolves during 1978-87 in 8,000 km^2 in the northeastern part of the province.

Research on wolves in Canada began with the pioneering work of Cowan (1947), includes the earliest telemetry study of this species (Kolenosky and Johnston 1967), and continues with at least 6 active studies in 6 jurisdictions. The work of Carbyn (1975, 1983) in Riding Mountain National Park, Manitoba, is the only ongoing long-term study of wolves and other canids and their interactions with ungulate prey species in Canada.

Management of wolves in Canada includes inventory, predator-prey research, harvest monitoring, international cooperation with the United States, control to reduce livestock depredations and benefit ungulates, and efforts to reduce human exploitation in wilderness reserves (Peterson 1986). Treaty Indians have unrestricted hunting privileges; their direct effect on wolves and indirect effects from harvesting prey species such as caribou (*Rangifer tarandus*) may influence wolf numbers across a broad area of northern Canada.

Gray Wolf: Alaska

In Alaska, wolves currently occupy most of their original range; about 1.3 million km^2 and 84% of the state's land area. Kodiak Island, the Aleutian Islands, and several large islands in southeastern Alaska probably never supported wolves. In early winter 1987-88, between 5,200 and 6,500 wolves occupied 24 of 26 game management units statewide (Alaska Dep. Fish and Game 1988). This estimate was similar to estimates for the previous 2 winters. Currently, wolf numbers in most areas of the state are thought to be stable or slowly increasing (Alaska Dep. Fish and Game 1988).

Wolves are classified as both big game and furbearers in Alaska. The hunting season for residents and nonresidents is from 10 August to 30 April, and bag limits differ by area and range from 2 to unlimited. Trapping seasons usually extend from November through March without a bag limit. Before 1988-89, wolves in much of the state could be taken on a trapping license after hunters pursued wolves with airplanes and landed nearby. Shooting from the air has been prohibited since 1972, but continues illegally; 2 documented instances in Denali National Park and Preserve involved several wolves during 1985-88. In 1988, regulations further restricted airplane assisted hunters to 7 game management units in interior Alaska and an annual bag limit of 10 wolves.

Melchior et al. (1987) reported that documented wolf harvests in Alaska ranged from 673 to 1,042 between 1978-79 and 1985-86. Reported harvests were 805 in 1986-87 and 1,067 in 1987-88. Hunters and trappers are required to register pelts of harvested wolves, but pelts used locally often are not recorded as part of the reported total take.

Alaska does not control wolves to reduce livestock depredations; predation on horses and domestic dogs is infrequent and there are few cattle, sheep, or poultry ranches. Wolf control programs to benefit moose (*Alces alces*) and caribou populations were initiated in 1975-76. During 1976-83 about 1,300 wolves were taken in several control programs in interior Alaska. Responses of ungulate populations to these control programs have been variable (Gasaway et al. 1983, Ballard et al. 1987), and wolf control was reduced to 1 area of interior Alaska by 1985. Attitudes of Alaskan residents toward wolf control currently range from strongly supportive to strongly opposed and seem to be related to their urban or rural residency.

Research on wolves and wolf-ungulate relationships in Alaska includes the pioneering work of Murie (1944) and more recent studies by Haber (1977), Stephenson and James (1982), Gasaway et al. (1983), Peterson et al. (1984), Ballard et al. (1987), and Mech (1989).

Peterson (1986) stated that the most important long-term threat to wolves in Alaska is increasing permanent human settlement. Although efforts to establish agricultural activities, transfer state-owned lands to private ownership, and initiate large hydro-electric projects in wilderness areas began in the late 1970s, some of these ventures either failed or proved infeasible. Permanent human settlement and its negative implications for wolf conservation are yet to occur over most of Alaska.

Red Wolf

Originally occurring from Texas to Florida and north to the Carolinas, Kentucky, southern Illinois, and southern Missouri (Young and Goldman 1944, Nowak 1970), the red wolf was widely thought to be abundant throughout the western third of its range as recently as the late 1950s and early 1960s (Hall and Kelson 1959, Burt and Grossen-heider 1964). However, McCarley (1962), after extensive study of skulls recently obtained from wild canids in the south-central United States, concluded that coyotes (*Canis latrans*) had replaced red wolves in most areas presumed to contain large populations of the latter.

McCarley's report prompted Pimlott and Joslin (1968) to conduct extensive surveys for remaining red wolf populations in 1964 and 1965. Based on results from howl-response techniques developed for use on gray wolves in Canada, they concluded that red wolves persisted only along the upper Texas Gulf coast and in extreme southwestern Louisiana. Based on similar methods, Russell and Shaw (1971) estimated that no more than 300 red wolves remained in coastal Texas by 1970.

The status of the red wolf was obscured partially because of its rapid replacement by coyotes and because of the tendency for local people to refer to wild *Canis* as "wolves." Hybridization between red wolves and coyotes has contributed to the confusion over the red wolf's status and poses the greatest threat to the remaining red wolves. Specimens of wild *Canis* from northeastern Texas and parts of Louisiana and Arkansas after the 1930s were intermediate in size between coyotes and specimens of red wolves collected before 1930 (Paradiso and Nowak 1971, 1972). As Mech (1970) suggested, hybridization probably occurred intermittently for centuries. These crosses probably had little influence upon either parental population when the zone of sympatry was small and both populations were numerous outside the zone.

By the 1930s, the red wolf had disappeared east of the Mississippi and persisted only in small, scattered populations in the western portions of its range. Fragmentation and social disruption of wolf populations, in addition to the range expansion of the coyote, increased opportunities of hybridization of wolves and coyotes and threatened the genetic integrity of the red wolf.

As a result of the Pimlott and Joslin (1968) survey, the International Union for Conservation of Nature and Natural Resources (IUCN) listed the red wolf as critically endangered in 1967, and the U.S. Fish and Wildlife Service listed it as endangered soon thereafter. The red wolf received federal protection with passage of the 1973 Endangered Species Act (U.S. Fish and Wildlife Service 1984).

The U.S. Fish and Wildlife Service (1984) initiated a recovery program for the red wolf in fall 1973. Conclusions from subsequent field investigations were that hybridization was too extensive even along the Texas Gulf coast for the species to survive much longer in the wild. Accordingly, emphasis shifted to a captive propagation program, centered at the Point Defiance Zoo in Tacoma, Washington (Carley 1975). Only 40 of 400 examined individuals from the Texas coast were considered sufficiently red wolf-like to qualify for captive breeding. The present population of red wolves is descended from only 17 animals removed from the wild (Parker 1988).

The red wolf populations of Texas and Louisiana now are thought to consist entirely of hybrids. Thus, survival of the species seems to rest entirely upon captive propagation and restoration.

In early 1988, there were 113 red wolves; 13 were free-ranging in North Carolina (W. T. Parker, Fish and Wildl. Serv., pers. commun.), 4 juveniles were on Bull Island, South Carolina, and 8 lived on Horn Island, Mississippi, as part of the propagation program. The remaining 88 were in 16 zoos and research centers.

Mexican Wolf

The Mexican wolf or lobo, formerly widespread in the temperate uplands of sub-Mogollon Arizona, southwestern New Mexico, Trans-Pecos Texas, and northern Mexico, has been extirpated from the wild in the United States and nearly so in Mexico (Brown 1983). The last authenticated breeding record of a Mexican wolf in the United States was on Fort Huachuca, Arizona, in 1944. In the United States, the last Mexican wolves were killed in Texas in 1970, in New Mexico in 1970, and in Arizona in 1975 (Brown 1983). These animals were considered to have been either transient males from Mexico or released captives. Reports of Mexican wolves since that time are unsubstantiated and may involve coyotes, dogs, or escaped or released captive wolves or wolf-hybrids.

The situation in Mexico is similar. In 1978, McBride (1980) estimated that 20 wolves remained in 2 areas in the state of Durango, another dozen or so in central Chihuahua, and no more than 50 in all of Mexico. The wolf's present status in Mexico is unknown, but must be regarded as close to extinction in its natural state.

The captive Mexican wolves are closely related (U.S. Fish and Wildlife Service 1982). Beginning in 1977, under a cooperative agreement between the United States and Mexico, wild Mexican wolves were captured for holding and breeding. Captive breeding efforts currently are conducted at the Arizona-Sonora Desert Museum near Tucson, Arizona; the Wild Canid Survival and Research Center near St. Louis, Missouri; the Rio Grande Zoological Park in Albuquerque, New Mexico; and the La Michilia Biosphere reserve near Suchil, Durango (U.S. Fish and Wildlife Service 1982). A large captive population of about 60 animals is needed to preserve the species' genome and support a restoration program. No wild-trapped animals are believed to be available for release.

WOLF SOCIAL ECOLOGY

The social ecology of wolves must be considered in the development of reintroduction plans. Gray wolves are highly social and live in packs of related individuals that range in size from 2 to >25 animals (Mech 1970). Mexican wolves have not been studied extensively, but may occur in smaller packs of 2-8 animals (Bednarz 1988). Red wolf packs of 2-11 have been recorded; however the social structure of this species has not been studied completely (Riley and McBride 1972, Carley 1979).

New packs of gray wolves are established by dispersing individuals that locate mates and reproduce (Rothman and Mech 1979, Fritts and Mech 1981). Packs establish and defend territories from 125 km^2 (Mech 1987) to over 2,541 km^2 (Ballard et al. 1987); ranges of unmated individuals are larger and are not defended (Fritts and Mech 1981). Summer activities center on home sites (den and rendezvous areas) that also serve as refuges for pack members at other times of the year (Harrington and Mech 1982). Densities of 0.6 to 4.3 gray wolves/100 km^2 have been recorded (Van Ballenberghe et al. 1975, Hebert et al. 1982, Carbyn 1987).

Gray wolf packs maintain territories by howling (Harrington and Mech 1979) and scent marking (Peters and Mech 1975). Wolves howl more frequently at home sites than elsewhere (Harrington and Mech 1983). Lone, unmated wolves scent-mark rarely, whereas newly formed pairs scent-mark frequently until they become established (Rothman and Mech 1979). Because of the large distances that dispersing individuals may move and the abundance of potential dispersers, individual gray wolves occur outside the species range in the lower 48 states (Fritts 1983, Mech 1987). However, the presence of unmated wolves is not evidence of successful recolonization, considering the abundance of such records (U.S. Fish and Wildlife Service 1987*a,b*). In most areas, the presence of breeding groups is easy to determine because mated pairs, especially newly-mated pairs, are vocal and their scent marking is conspicuous, at least in accessible areas.

CONSERVATION BIOLOGY

Genetics

Consideration of genetics is relatively new in conservation. Until recently wildlife biologists had little concern for effects of genetic drift or inbreeding, in part because of the lack of empirical findings among free-living wild vertebrates. This lack of concern was reinforced by widely successful reintroductions of white-tailed deer (*Odocoileus virginianus*), wild turkeys (*Meleagris gallopavo*), and other game species; many were founded by a few individuals. Declines in reproduction and survival of young among inbred populations of wild species in zoos caused widespread reevaluation of genetics and conservation (Ralls et al. 1979), and led quickly to the emergence of conservation genetics as a scientific discipline (Schonewald-Cox et al. 1983).

Drawing upon established theories in population genetics, conservation geneticists explained the differences between the success of reintroduced game species and the failure of many zoo populations. The long-term retention of genetic variability rests on 2 components (Franklin 1980, Soule 1980). The first, founder group size, probably was overestimated in importance. The second, maintenance of population size, was underestimated. Both reintroduced game populations and captive-reared zoo populations commonly were founded by only a few individuals. Game populations often expanded and came into contact with one another or with extant native populations. As formerly isolated populations merged, they greatly increased the maintenance population size.

Because of limited space, zoos must maintain each generation at much lower numbers than in the wild. This difference in maintenance population size probably accounts for most of the differences in the success of the restored game populations and their zoo counterparts. This difference does not, however, account for the persistence of isolated populations such as moose and wolves on Isle Royale, although insufficient time may have passed since these 2 species colonized that island for genetic heterozygosity to be lost.

A genetic model was developed by Ulysses Seal and Tom Foose to help set population goals for the red wolf--assuming that it is a genetically distinct species. The model used the number of founders (17), the size of the actual population (85), and other specific characteristics of the red wolf population and indentified goals of an actual population size of 220 wolves in the wild, augmented periodically from a captive population of 330 wolves (Anon. 1988).

No such estimate yet has been made for the gray wolf, but it may be quite different. Because the gray wolf is far more numerous over a much greater geographic range than the red wolf, it presumably contains substantially more overall genetic variability than the red wolf. Moreover, its social behavior, movements, and dispersal patterns may differ from those of its close relative.

Theoretical considerations aside, the Isle Royale wolf population that was almost certainly founded by a population of 2 wolves has survived for 40 years. Although the population was at an all-time low in spring 1989, at least 1 new litter of pups was produced (R. O. Peterson, Michigan Tech. Univ., pers. commun.). Thus, the low of 11 Isle Royale wolves may be no more significant a deviation biologically than the population high of 50 animals.

Estimated necessary wolf populations for maintaining genetic variability and for avoiding inbreeding depression will be approximate at best. Current methods offer only broad guidelines. Reintroductions of wolves into areas where they likely will remain isolated from other populations may require further reintroduction of some individuals every few years to maintain genetic variability. Several methods for systematic monitoring for levels of genetic variability have been recommended

(Lande and Barrowclough 1987).

Minimum Viable Populations

Small, isolated populations are more likely to become extinct than large, contiguous populations within any specific time period. In recent years, however, this readily apparent association has been refined and developed into the concept of minimum viable population (MVP). Demographic, environmental, and genetic uncertainties and the risk of natural catastrophes form the basis for estimating MVPs. Early efforts (Shaffer 1981) attempted to establish arbitrary levels of MVP for survival probability over a specified period; e.g. a 99% chance of surviving for 1,000 years.

Even though MVP currently does not provide precise estimates of the numbers needed to ensure an acceptable chance for survival over a specific period, it provides conceptual and analytical tools for wolf restoration. Even very rough estimates of MVPs in combination with information on home range, social behavior, and dispersal data can furnish improved estimates of minimum area requirements (MAR) for a new population. One recent MVP model, for example, suggested that no more than 22% of the world's national parks are big enough to sustain populations of large carnivores for 100 years, and none can sustain large carnivores for 1,000 years (Belovsky 1987).

One implication of such a conclusion is that national parks and biological reserves have to be substantially enlarged before they can act as self-sustaining ecosystems. The most difficult component of a natural ecosystem to maintain in an area will be large carnivores at the top of the food chain.

Current MVP models suggest other management possibilities for large carnivores. If national parks and other protected areas cannot provide large enough areas for self-perpetuating populations of wolves, systematic and periodic reintroduction of wolves from outside may ensure population survival. Obviously, such a management approach requires maintaining healthy wolf populations elsewhere, preferably in a wild state.

Finally, considerations other than MVP may be more suitable for estimating the desired size for reintroduced wolf populations, at least for the gray wolf. A primary justification for restoration of wolves is the restoration of a top predator to the ecosystem. Enough is known about wolf predation on ungulate populations to allow estimation of population sizes that are ecologically functional rather than just minimally viable (Conner 1988), and such ecological estimates should at least supplement estimates by MVP theory for decisions on wolf population size.

Perhaps the most important point concerning MVP theory is that it seems to be a sound but untested concept. This shortcoming can be remedied in large measure through the detailed monitoring of reintroduced populations, isolated populations, or both. Such field data together with refinements in the MVP models can greatly improve the utility of the minimum viable population concept in conservation.

HUMAN DIMENSIONS OF WOLF RESTORATION

Decisions about when, where, and how to reintroduce wolves depend upon social values as much as ecological considerations (Clark and Kellert 1988). Although ecological considerations are fundamental, an enormous range of policy options is possible that reflects competing and interacting human values, socioeconomic pressures, regulatory mandates, and administrative attitudes and behavior.

Values and Attitudes

Kellert (1980*a*) developed a typology to describe basic human attitudes toward animals that can be used to consider perceptions and values about wolves. Historically, wolves have been perceived in negativistic, utilitarian, and dominionistic terms (Goldman 1944, Young 1946, Matthiessen 1959, Dunlap 1988). As views of wildlife, especially predators, shifted during the 20th century, the wolf became a symbol of human persecution of animals. Popular books (Mowat 1963, Lopez 1978), films, and television programs reflected this basic attitude change. Indicative of this new perspective, the gray wolf was among the first species to be officially listed as endangered after passage of the Endangered Species Conservation Act in 1969. Aldo Leopold's career reflected this profound shift in American consciousness toward the wolf. Initially a strong advocate of wolf control, Leopold (1949) later recognized this animal's biological and symbolic significance in the preservation of wilderness and sustainable ecosystems.

Among many in contemporary North America, however, the ambivalence remains. The wolf embodies new virtues of wilderness and ecology for some, whereas for others, particularly its old agricultural adversaries, the wolf remains a vicious killer. This wide variation in contemporary attitudes toward the wolf has been documented in several recent studies.

Lewellyn (1978) and Kellert (1980*b*) reported widespread variations in attitudes toward wolves and coyotes. Nearly as many Americans had negative as positive views of these species. Most favorable perceptions were among wildlife advocates from urban areas and coastal states. Agriculturalists, particularly livestock producers, and to a lesser extent, residents of the South, respondents over 55 years of age, persons of less than high school education, and nonwhites expressed negative views. A strong correlation between negative attitude and lack of factual knowledge about the wolf was noted by Llewellyn (1978) and Biggs (1988). Highly antagonistic views of predators among livestock producers are common (Buys 1975, Kellert 1986, Biggs 1988, Bath and Buchanan 1989). Ranchers seem to be unwilling to change their views on wolf restoration, even if offered financial compensation for losses of stock (Stuby et al. 1979, Kellert 1980*c*). Llewellyn (1978) and Kellert (1986) found unfavorable perceptions among about 25% of the people living close to the wolf in Minnesota. Hook and Robinson (1982) reported that opposition among rural, lower income, male hunters and a general distrust of government were involved in the animosity toward restoration of wolves in upper Michigan. Of the 4 introduced wolves, one was killed by a car, one was shot by a person plinking with a .22 rifle, one was caught accidentally by a coyote trapper, and one was killed by a deer hunter.

Kellert (1983) and Burghardt and Herzog (1988) suggested that negative perceptions of the wolf may be associated with fears about their presumed dangerousness, predatory nature, potential threat to human property, wilderness associations, traditional cultural, historical antipathies, and perhaps to their nocturnal behavior. Negative attitudes toward wolves may be related strongly to hostile depictions of this animal in various myths, childrens' stories, and literature depictions (Johnson 1974, More 1978). In an investigation of views of predators, Arthur et al. (1977) found that of 16 species examined, hostile perceptions of wolves were exceeded only by attitudes toward skunks.

Kellert (1986) and Tucker and Pletscher (1989) found that most respondents supported the right of farmers to protect their stock from wolf predation and opposed limits on human settlement as a means of protecting wolf habitat. Most favored control of only the offending animal and the use of nonlethal methods such as relocation, guard dogs, and improved husbandry. These findings supported those of Stuby et al. (1979) and Kellert (1985) on the control of depredating coyotes and by Biggs (1988) on attitudes of New Mexico residents about the possible restoration of Mexican wolves. Kellert (1986) found that most respondents in Minnesota opposed wolf reductions as a means of increasing deer and other game animal populations, as did Bath's respondents (1987) to a survey of members of the Wyoming Wildlife Federation. Most of the Minnesota public expressed skepticism toward harvesting wolves for pelts, although a limited harvest was endorsed by a majority of trappers and deer hunters; these findings were corroborated by Tucker and Pletscher (1989) in Montana. A majority of hunters and residents west and adjacent to Glacier National Park, where naturally recolonizing wolf packs are present, expressed positive views on wolf recovery (Tucker and Pletscher 1989). However, a minority voiced fear of wolves as a threat to human safety and opposed having wolves in the area.

McNaught (1987) found strong support for wolf restoration among the majority of Yellowstone National Park visitors in summer 1987 for a variety of ecological, aesthetic, and outdoor recreational reasons. Significantly less support for wolf restoration was found among older respondents, lodge guests as compared to campers, and the less educated individuals. McNaught (1987) found stronger support for wolf restoration among local park visitors from Wyoming, Idaho, and Montana than among persons residing outside the region, as well as stronger pro-wolf sentiments among persons with part-time livestock-raising experience compared to full-time livestock producers. These respondents were park visitors and not representative samples of local area residents or full-time ranchers. Defenders of Wildlife and Wyoming Wildlife Federation members viewed the wolf positively and supported the wolf restoration to Yellowstone, although Defenders members generally expressed stronger pro-wolf sentiments than Federation members (Bath 1987).

Regulatory Issues

Two issues are of particular concern: (1) legal mandates and interpretations that could affect the nature and course of wolf restoration, and (2) administrative and organizational factors relating to the ability of regulatory agencies to implement wolf restoration policy effectively and efficiently. Unfortunately, systematic studies of these subjects are lacking.

Goldman-Carter (1983) and Coggins and Wilkinson (1987) illustrate the utility of considering reintroduced wolves as nonessential experimental populations. Population management involving animal-damage control and harvesting of wolves as game animals has been prominent in recent court cases involving wolves. For example, the legal decisions in *Fund for Animals* vs. *Andrus*, 11 Environmental Reporter Cases 2189 (District Minnesota 1978) and *Sierra Club* vs. *Clark*, 755 Federal 2d 608 (8th Circuit 1985) seemed to have placed fairly strict limits on the extent of administrative discretion permitted in managing a federally listed threatened or endangered species, particularly in the context of controlling livestock depredations and the acceptability of an annual harvest.

Additionally, although more ambiguously, the courts seemed to have emphasized the primary responsibility of the federal rather than state governments in the management and conservation of a federally listed endangered or threatened species. In *Fund for Animals* vs. *Andrus* the courts, although allowing control of depredating wolves, precluded indiscriminate taking of nonoffending animals and, in effect, mandated control regulations based on conclusive biological and economic considerations. In *Sierra Club* vs. *Clark*, the court suggested that a sport season or annual harvest of a threatened species was conceptually inconsistent with Congress' intent in passing the Endangered Species Act. More ambiguously, the court, by effectively denying state-proposed management, may have, as in *Palila* vs. *Hawaii Department of Land and Natural Resources*, 649 Federal Supplement 1070 (District of Hawaii 1986), discouraged state agency participation, but the opinion did not suggest that federal management of listed species was enlarged.

No empirical research has been conducted on administrative implementation efforts to manage and conserve wolves, other than the work of Weaver (1987). However, Yaffee (1982), Clark and Harvey (1988), and Clark et al. (1989), emphasized the importance of the effect of the regulatory agency on the success or failure of endangered species recovery efforts.

Clark and Harvey (1988) stressed the importance of the following organizational characteristics as means of facilitating effective recovery programs: (1) decentralized decision-making abilities, (2) open flow of communication between managers and scientists, (3) avoidance of rigid bureaucratic structures characterized by an inordinate concern for power and control instead of goals, (4) retention of flexible and creative decisionmaking capacities, (5) fostering feedback procedures for assimilating new information, and (6) institutionalization of clear accountability and performance standards. These authors note that although agencies must respond to social and political considerations, they also need to be vigilant in avoiding undue external group influence, particularly "capture" by pressure groups motivated more by self-serving than by species-recovery objectives.

Rigid restrictions to management of wolves by the Endangered Species Act prompted amendment of the Act in 1982 to provide for an experimental population designation for reintroductions (Section 10[j] of the Act; Public Law 97-304). This provision allows flexibility in managing introduced populations that does not apply to wolves that naturally recolonize an area--they continue to be classified as endangered. Experimentally designated populations are treated as nonessential, which allows their management to be tailored to the specific situation by afford-ing reduced protection under Sections 7 and 9 of the Act (Parker 1989). The nonessential designation also is appropriate because wolves exist in many populations across Canada and Alaska. The red wolf is considered secure in widely separate captive breeding programs and zoos in the United States (Fed. Reg. 51[223]:41792, 19 Nov. 1986). This amendment alleviated some concerns among agricultural- ists about protecting livestock from depreda- tions. Because tolerance to the presence of wolves is low among some groups, maximum flexibility to manage wolves is necessary to reduce human conflict.

Because the human dimension is so significant to wolf restoration, one of the most important needs is public education about wolves. Such education must be factual and objective, both exposing the myths about wolves and admitting the negative aspects of wolf relations with humans. It should be taught in schools, nature centers, museums, and special forums, and should include the mass media. State and federal agencies should be involved.

Research on wolf-livestock relations also is necessary; particularly study of factors predisposing livestock to wolf predation, nonlethal methods of preventing or alleviating depredations, and more effective and selective means of controlling wolves in extensive mountainous terrain. The results of this research and information about livestock husbandry practices that minimizes losses to predation should be made widely available to the public through extension programs.

METHODS OF REINTRODUCING WOLVES

Griffith et al. (1989) point out that the most successful translocations are those that occur in high quality habitat well within the original range of the species. All potential translocations of wolves are in the original range of the species. Best habitats for this obligate carnivore have an adequate prey base, sufficient size, and relatively low levels of human activity.

The main problem with reintroduction is the tendency of translocated wolves to move long distances, apparently attempting to return home (Weise et al. 1975, Henshaw et al. 1979, Fritts et al. 1984). Because wolves range so widely, if they leave the intended reestablishment site, they may settle in areas where they could feed on livestock and cause serious public relations problems.

Past releases indicate that holding wolves in a pen at or near the release site seems to disrupt their roaming and homing tendency, and that these tendencies are weakest in young wolves. Restricted movements were exhibited by 4 6-9-month-old gray wolves translocated in Minnesota, even though they had not been held in a pen at the release site (Fritts et al. 1984). Likewise, 2 9-month-old red wolves exhibited restricted movements after just 1 week in a holding pen constructed at the release site (M. K. Phillips, Fish and Wildl. Serv., pers. commun). A yearling and a 2-year-old red wolf both stayed at the release area after having been acclimated for only 80-82 days (Phillips 1988*a,b*). Thus, most young wolves seem to exhibit restricted movements even in the absence of a lengthy acclimation period. Disadvantages of using young-of-the-year for reintroductions are that they are not as experienced in hunting as adults and may not breed until 2-4 years old.

Adult wolves can be expected to roam more widely than younger wolves. Three adult gray wolves held for 1 week in a pen at the release area in Michigan moved widely after release (Weise et al. 1975). Two adult, wild, red wolves held for 6 weeks ranged outside the release area (Carley 1977), whereas another pair held in the same area for 6 months remained in the area after release (Carley 1980). Four other pairs of red wolves that were born and raised in captivity and held in a pen at their release sites for 10 to 10 1/2 months remained near the release sites (Phillips 1988*a,b*). Older animals may be more likely to remain near the release site if held in a pen for at least 6 months.

To encourage reestablished gray wolves to prey on a particular species of ungulate, the stock for release should be captured from an area where it preyed primarily on that species. While wolves are held at the release site, they should be fed prey of the target species. In addition, carcasses of such prey should be stockpiled to help subsidize the wolves for several weeks after release. Work with reintroduced red wolves indicated that some captive-born animals may take a few weeks to learn to feed themselves consistently and that supplemental feeding can be successful (Phillips 1988*b*).

All released wolves should be radio-collared and tracked so their fate and movements are known. Not only will this information allow an ongoing assessment of the reintroduction, but it also will help anticipate problems that might be caused by the wolves straying from the release area and will provide valuable data for other releases. Consideration should be given to the use of capture collars (Mech et al. 1984, 1990) that will allow recapture of straying individuals at will. Telemetry systems that can be turned off and on with remote controls (Mech et al. 1990) should be considered where radio signals may be monitored by poachers.

Because the Mexican wolf is now extirpated in the United States and is nearly so in Mexico, reestablishing this controversial animal will be doubly difficult. A suitable release site must be found and the reintroduced stock must consist of captive-bred animals without a demonstrated ability to survive in the wild. Simply releasing animals in suitable habitat with an adequate prey base will not suffice. The introduced wolves must successfully form a social unit, learn to hunt, establish a home range, reproduce, and survive. All of these behaviors will be especially important in the recovery effort because throughout the region human attitudes are likely to be hostile.

All releases should be restricted to "Wolf Management Areas" (WMA), and wolves would be considered part of an experimental population under subsection 10(j) of the Endangered Species Act. The proposed release sites would be divided into 2 parts: a "primary wolf management area" of sufficient size to support a small number of wolf packs that are totally protected and managed, and a "secondary wolf management area" where roaming wolves would be granted some measure of tolerance and be subjected either to recapture or supervised control measures. Wolves in all other areas should not be protected and would be subject to control measures.

Ideally, all or significant portions of the primary WMA already should be retired from livestock grazing (the Gila Wilderness Area in New Mexico where many livestock allotments have been retired for use by game animals would be an ideal WMA). Cow-calf operations should, if feasible, be changed to steer operations on any remaining ranches in WMAs. Ranchers in and outside WMAs should be compensated for livestock losses verified by Animal Damage Control personnel of the U.S. Department of Agriculture. This could be done through an indemnity bond or reduced or suspended grazing fees in WMAs.

Red Wolf Program

The Red Wolf recovery program relies exclusively upon captive propagation (U.S. Fish and Wildlife Service 1984). Successful recovery requires suitable, essentially coyote-free restoration sites in the original geographic range of the species.

In 1984, the Prudential Insurance Company donated nearly 120,000 acres of undeveloped swamp and marsh in coastal North Carolina to the U.S. Fish and Wildlife Service. These lands became the Alligator River National Wildlife Refuge. The refuge was considered an ideal site for the reintroduction of red wolves because it is in the historic range of the species, sparsely settled, and sufficiently isolated to facilitate management of the wolves and to restrict coyotes and feral dogs. In conjunction with adjacent Department of Defense lands, it is large enough to support a wolf population (Phillips and Parker 1988).

Briefings of North Carolina congressmen, the North Carolina commissioner of agriculture, the governor's staff, the North Carolina Wildlife Resources Commission, and 4 public meetings were held early in 1986 to gain local public support for restoration of red wolves. This support was the key to allowing the restoration to proceed (Parker 1988).

Four pairs of red wolves that spent 10 months in acclimation pens were released in September 1987 (Phillips and Parker 1988). Two females died in early winter and their mates were recaptured and repaired with replacement females soon thereafter. These new females and the 2 original males were released in April 1988 (Phillips 1988*b*).

Meanwhile, another pair of red wolves was placed in the acclimation pen at Bulls Island, where it bred and produced 4 pups in late April 1988 (Parker 1988). Two pups survived, and they and their parents were released in July 1988. The adults had radio collars and the pups carried surgically implanted transmitters. Late that same month, the adult female was found dead after having been killed, apparently by an alligator. The male continued to tend the pups, and in January

1989, the pups were recaptured and taken to the Alligator River Refuge where they were released, thus completing the first cycle of the island propagation strategy. Since their release, the pups established a home range that includes the release site. Inspection of scats and observations of the wolves indicate they were feeding themselves and were in good health as of 20 July 1989 (M. K. Phillips, Fish and Wildl. Serv., pers. commun.).

Development of a second propagation site on Horn Island, Mississippi, began with the introduction of a pair of red wolves on 10 January 1989. As with the Bulls Island wolves, pups produced on Horn Island eventually will be transported to the Alligator River Refuge.

The steps in the red wolf restoration can be summarized as follows: (1) location of a site with acceptable biological criteria and with sufficient areas of protected habitat, (2) extensive efforts to educate the public and its local leadership about the values of the restoration and the precautions to be taken by those involved in the recovery, (3) construction of acclimation pens, (4) release of radio-marked wolves, and (5) monitoring of the wolves and reevaluation of the methods based on new data.

These restoration sites are coyote-free, but because of the coyote's propensity for range expansion, no one can be certain that the threat of hybridization will not emerge again. Nonetheless, red wolf populations may expand and exclude the coyote, as they presumably did for centuries. This issue must be assessed as red wolf restoration proceeds.

Because of the limited numbers of red wolves, both in captivity and in the wild, plans are underway both to expand permanent captive populations to augment those established in the wild and to restore them to Great Smoky Mountains National Park and other areas. Because of the remoteness of the reestablished populations and little or no chance that they will ever become contiguous, such an arrangement seems biologically essential.

WOLF MANAGEMENT

Depredation On Livestock and Pets

Wolves inevitably will encounter livestock and pets that also inhabit the recovery areas. Experience in Minnesota and western Canada suggests that losses of livestock will be low and can be managed by controlling individual offending wolves (Fritts 1982, Gunson 1983). Management plans for individual wolves that prey on pets at campgrounds or other installations should be developed before restoration. Fritts and Paul (1989) found that some wolves persist in preying and feeding on dogs, thereby posing a local but substantial problem. Control of wolves preying on livestock and pets is imperative and should be prompt and efficient if illegal killing is to be prevented and human tolerance of the presence of wolves is to be maintained.

Exploitation of the Prey Base by Humans

Exploitation of ungulates by humans in northern ecosystems where wolves, black bears *(Ursus americanus)*, grizzly bears (*Ursus arctos*), and mountain lions (*Felis concolor*) also occur may result in a wide variety of responses by ungulate populations, including depression of prey to lower numbers than in the absence of predators (Bergerud 1974, Gasaway et al. 1983, Messier and Crete 1985). Declines of ungulate populations initiated by severe winters, habitat deterioration, or hunting may be accentuated by wolves and possibly other predators. Subsequent to these declines, population increases may be delayed when wolves are present (Mech and Karns 1977, Gasaway et al. 1983, Ballard and Larsen 1987). Such conditions are relatively rare; many ungulate/gray wolf/bear complexes in North America are exploited by humans without driving ungulate numbers to low levels. But when management goals strive to increase ungulate harvests by humans or restore depressed ungulate populations to much higher densities, wolf population management must be considered. Nevertheless, strong opposition in Alaska and northwestern Canada in recent years has reduced the number and duration of wolf control programs (Williams 1988).

Gauthier and Theberge (1987) reviewed recent literature on ungulate/wolf/bear relationships and drew 9 broad conclusions:

1. Wolves primarily eat large ungulates, but their intake of small mammals may be high during summer or when large ungulates decline.
2. Wolf and bear predation can significantly reduce survival rates of young ungulates during the calving and summer periods.
3. Winter weather and winter forage availability are important influences on ungulate vulnerability to predation. Younger ungulates (including yearlings) seem to be more vulnerable than older ungulates.
4. Prey switching by wolves can maintain or increase their predation rate on primary ungulate prey, increase the rate of ungulate prey decline, and maintain subsequent low ungulate densities.
5. Wolf predation can be compensatory with starvation when an ungulate population is at or near maximum numbers as determined by food and climate.
6. Hunting by humans usually is additive with wolf predation on ungulate populations.
7. Wolf numbers largely are determined by the per capita biomass of available food resources. This relationship is influenced by social factors that may reduce the wolves' breeding rate and result in time lags in the response of wolves to changes in ungulate prey numbers.
8. Where wolves and brown bears are copredators of an ungulate species, bears can reduce ungulate numbers more than wolves because of their effect on younger prey. Co-predators likely reinforce the regulatory effect of predation if they, in combination, depress prey populations more than only 1 predator.
9. Where wolves are the dominant predator of an ungulate species and prey numbers are below carrying capacity, a significant reduction in wolf numbers can produce increases in the number of ungulate prey.

Connolly (1978) presented a broad framework of management questions about predator control. Theberge and Gauthier (1985) and Gauthier and Theberge (1987) expanded that framework and applied it specifically to gray wolf control, emphasizing the importance of good biological information on predator and prey numbers and the need to assess carrying capacity of prey before implementing wolf reductions. Methods of crudely estimating the impact of predation, short of conducting long-term research, include assessment of predator:prey ratios (Keith 1983) or predator:prey biomass ratios (Mech 1970) that involve ranges of empirically derived values (Gasaway et al. 1983) identifying thresholds of regulating effects. Recent work in Alaska suggests that prey:biomass ratios have promise as predictors of caribou population trends in multiprey bear/wolf ecosystems (Van Ballenberghe 1989). These results imply that managers must strive to keep prey biomass high in relation to wolf numbers to avoid sharp ungulate declines and resulting controversial wolf control programs (Van Ballenberghe 1985).

If wolf control is implemented, a variety of techniques are available, ranging from trapping to shooting from aircraft to poisoning. Large-scale programs to remove 40% or more (Keith 1983) of gray wolf numbers over large areas of Alaska and northwestern Canada have employed shooting from helicopters and fixed-wing aircraft. In more settled areas with better access, trapping may be as effective (Van Ballenberghe et al. 1975). For closely monitored wolf populations with radio-collared animals, selective pack removals (Haber et al. 1976) or efforts to reduce radioed packs to pairs or trios (Ballard and Stephenson 1982) may be effective. Wolves may rapidly recover from control programs through immigration and reproduction (Ballard et al. 1987); these results suggest that wolf control must be considered an acceptable management option.

In wilderness areas where gray wolf populations will be recovered and big game is hunted, wolves must be managed at levels compatible with hunting activity appropriate for wilderness. Currently, little effort is made to manage hunting of big game populations at levels appropriate to wilderness values. When established, wolves are a component of the wilderness values and allowable take of big game by hunters must consider their presence. Harvests may be reduced in wilderness areas in some instances (J. M. Peek and D. J. Vales, unpub. rep. to U.S. Fish and Wildl. Service, Helena, Mont., 1989). Hunter harvest, big game population trends, wolf-prey interactions, and wolf population trends will have to be accurately monitored.

Enhancement of the Prey Base

Reestablishment should not be attempted in areas without an adequate prey base. In some areas, particularly Europe, prey populations themselves first must be enhanced. This can be done by tighter restrictions on prey harvesting, by habitat manipulation, and in extreme cases by prey restoration. Only after adequate prey is restored should plans be made to reestablish wolves. This recommendtion should not be construed to apply to wilderness areas with substantial prey populations where inclusion of wolves may mean reductions in harvest by hunters.

CONCLUSIONS

To succeed, wolf restoration efforts must include extensive public involvement. The values, attitudes, interests, concerns, and understandings of various constituent and public interest groups must be given particular attention. In addition, intergovernmental and legal considerations should be adequately considered and understood. Finally, administrative issues, particularly the behavior and performance of regulatory agencies, must be recognized and evaluated as a critical determinant of endangered species recovery efforts. Successful restoration of wolves to wild environments will reflect our ability to match effectively the biological potential of this species with the needs and interests of various human population groups, within the constraints and capacities of our legal and regulatory system.

Reintroductions should be made in areas with substantial wilderness character and adequate prey populations, where conflicts with livestock are least likely, and where local support is prevalent. Reintroduced wolves should be radio-collared for monitoring locations and activities. Wildlife management agencies should ensure that provisions to carry out this monitoring process are adequate. Monitoring will be a crucial part of ongoing management programs.

Plans to rapidly address livestock depredations must be integral to wolf restoration programs. The livestock industry needs to be assured that its concerns are addressed. Reintroduced wolves in wilderness areas where big game is hunted should be designated experimental populations for maximum flexibility in management of their populations.

Criteria for evaluating the success of a restoration must include assessment of population trend and reproductive success. Designation of specific population size is less important than assessment of occupied area, population trend and performance, and measures of human tolerance. Minimum viable population levels must include genetic considerations. Augmentation from other populations may be necessary for maintaining genetic diversity in isolated populations.

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