The Challenge and Opportunity of Recovering Wolf Populations

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Abstract: *The gray wolf once inhabited a wide variety of habitats throughout most of the northern hemisphere north of 20°N latitude. Because the animal preyed on livestock and competed with humans for wild prey, it was extirpated from much of its range outside of wilderness areas. Environmental awareness in the late 1960s brought for the wolf legal protection, increased research, and favorable media coverage. The species has increased in both Europe and North America, is beginning to reoccupy semiwilderness and agricultural land, and is causing increased damage to livestock. Because of the wolf's high reproductive rate and long dispersal tendencies, the animal can recolonize many more areas. In most such areas control will be necessary, but the same public sentiments that promoted wolf recovery reject control. If wolf advocates could accept control by the public rather than by the government, wolves could live in far more places. Insistence on government control discourages some officials and government agencies from promoting recovery. The use of large- or small-scale zoning for wolf management may help resolve the issue. Public education is probably the most effective way to minimize the problem and maximize wolf recovery, but the effort must begin immediately.*

El desafío y la oportunidad de las poblaciones de lobos en recuperación

Resumen: *En su momento, el lobo gris habitó la mayor parte del hemisferio norte al norte de los 20° latitud norte, a lo largo de una gran variedad de hábitats. Este animal fue extirpado de la mayor parte de su rango de distribución en áreas no incluidas dentro de zones naturales debido a que predaba sobre ganado y competía con los humanos por presas silvestres. La concientización ambiental de fines de los década de los 60s trajo consigo la protección legal del lobo así como también un aumento en la investigación científica y la cobertura favorable de los medios de difusión sobre esta especie. Esta especie ha aumentado en abundancia tanto en Europa como en América del Norte y está comenzando a recolonizar tierras seminaturales y agrícolas y está causando un aumento en el daño al ganado. Debido a su alta tasa reproductiva y tendencias de dispersión a gran distancia, el lobo puede recolonizar muchas más áreas. El control de esta especie se hará necesario en la mayoría de tales áreas. Sin embargo, los mismos sentimientos públicos que promovieron la recuperación del lobo rechazan tal control. Los lobos podrían vivir en muchos mas lugares si los defensores de los lobos pueden aceptar un control por parte del público antes que por parte del gobierno. La insistencia sobre un control gubernamental desalienta a algunos funcionarios y agencias gubernamentales de promover la recuperación del lobo. El uso de una zonificación en el manejo de los lobos, a gran o pequeña escala podría ayudar a resolver este problema. La educación pública es probablemente el camino más efectivo para minimizar el problema y maximizar la recuperación de los lobos, pero la acción debe comenzar en forma inmediata.*

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Introduction

The gray wolf (*Canis lupus*) was one of the first highly visible animals to be included on the U.S. Endangered Species list. The creature now symbolizes endangered species and has become the cause célèbre of numerous animal-interest groups. Probably because of the affinity of the wolf to the dog (*Canis lupus familiaris*) and certainly because the species has historically been so persecuted (Young & Goldman 1944), a new mythology about the wolf has evolved; the vile wolf has been replaced by the unjustly persecuted wolf.

As this deification took place, remnant wolf populations were relegated to only the most pristine wilderness of North America and the least developed parts of the rest of the world. Thus, both laypeople and resource managers widely believed that wolves preferred wilderness. The animal came to symbolize wilderness, "for wolves and wilderness are inseparable..." (Theberge 1975:152).

However, the wolf survived only in wildernesses mostly because it was exterminated everywhere else. After the U.S. Endangered Species Act of 1973 protected the wolf in the 48 contiguous United States as of 1974 and public attitudes about wolves improved, wolves began to colonize a wide variety of habitats and to demonstrate that they did not require wilderness. The wolf has begun to recover in the northern U.S. and in several parts of Europe. The question of the next decade will not be how to save the wolf, but rather how best to manage the animal. This paper traces the history of the wolf's status and recovery and explores the dilemma of its management.

History and Persecution

Originally, gray wolves were distributed throughout the northern hemisphere in every habitat where large ungulates were found. Saturating most of the region between 20°N latitude (mid-Mexico and India) and the North Pole, in temperatures from $-40°$ to $+40°$ C, the wolf inhabited areas as diverse as Israel and Greenland.

Every kind of northern ungulate, as well as beavers (*Castor canadensis*) and arctic hares (*Lepus arcticus*), can serve as prey for wolves, and wolves easily switch their prey from wild to domestic species. Conflict between wolves and humans over domestic animals probably became an issue soon after ungulates were domesticated.

As firearms, poisons, and traps were developed, they were used ruthlessly against wolves with devastating effectiveness (Young & Goldman 1944). In Eurasia, most wolf populations reached their lowest point between the 1930s and the 1960s (Pimlott 1975; Delibes 1990; Promberger & Bibikov 1993). In the more-developed regions of Eurasia, wolves disappeared except in the central Appenine Mountains of Italy, the Cantabrian mountains of northern Spain, the Carpathians of Eastern Europe, the northern parts of the former Soviet Union, and the central plains and mountainous regions of Asia. Some populations also remained in the deserts of the Middle East. In North America, wolf numbers were lowest in the late 1950s. Populations survived primarily in Canada and Alaska (Mech 1970). In the 48 contiguous United States, only the wilderness of northern Minnesota and nearby Isle Royale National Park in Lake Superior held wolves.

The Environmental Revolution

The environmental revolution ushered in the first endangered species legislation in the U.S, the Endangered Species Act of 1966. This act did not protect endangered species but only encouraged federal agencies to give them special consideration and to promote their recovery.

At this time, about the only information available on wolves was anecdotal and hearsay. Historical notes by Young and Goldman (1944) and Murie's (1944) field study on Mt. McKinley wolves were practically the only available published information. A few more studies followed. After the considerable publicity produced by Durward Allen's seminal investigation of the wolves and moose of Isle Royale National Park, published in *National Geographic* (Allen & Mech 1963), wolf studies proliferated. In 1967, the first wolf symposium was held by the American Society of Zoologists, culminating in the publication of the proceedings in the May 1967 issue of *American Zoologist*. By then the full force of the environmental movement could be felt. Private wolf organizations sprang up in many areas, and the wolf quickly gained a popular constituency in the U.S. and abroad.

In Italy, Luigi Boitani and Eric Zimen pioneered a study of the wolf in the Abruzzo Mountains east of Rome (Zimen 1981; Boitani 1986). The World Wildlife Fund and the International Union for the Conservation of Nature and Natural Resources (IUCN), now the World Conservation Union, took great interest in the wolf, and the animal was listed in the IUCN's Red Data Book of endangered species. The IUCN Wolf Specialist Group was formed in 1973 (Pimlott 1975).

Meanwhile, radio tracking was developed in the early 1960s (Cochran & Lord 1963), a technique especially valuable to wolf research. Wolves were difficult to study with traditional methods because they were restricted to wilderness areas, highly elusive, and low in population density. Kolenosky and Johnston (1967) first radio-tracked wolves in Ontario. Mech and Frenzel (1971) then combined that technique with aerial tracking and

observation, and numerous studies using these techniques followed.

The second U.S. Endangered Species Act was passed in 1973 and protected the wolf in the contiguous 48 United States beginning in August 1974. Recovery teams were appointed by the U.S. Fish and Wildlife Service for three wolf subspecies, the eastern timber wolf, the northern Rocky Mountain wolf, and the Mexican wolf, as well as the red wolf (U.S. Fish and Wildlife Service 1975, 1982*a*, 1982*b*, 1987). At first many wolves were killed illegally (Mech 1977), but eventually that number dropped (Fuller 1989) and wolf reservoir populations in less accessible areas expanded (Fuller et al. 1992). They first recolonized the more remote areas surrounding their wilderness habitat, reinforcing the view that they were creatures of the wilderness.

Much of the public misinterpreted the wolf's endangered status in the 48 contiguous states, thinking it meant that no wolves were left anywhere else in the world. Private groups began to raise wolves to help restore populations, not realizing that Canada alone supported 50,000 of them. The wolf's apparent dependence on the wilderness was quantified in the 1970s and 1980s using road density as a measure. Roads were the routes by which the public and the government had been able to reach wolves to kill them. Thiel (1985) found that recolonizing wolves in Wisconsin lived only where the road density was less than 0.6 km/km^2, a figure corroborated for Michigan (Jensen et al. 1986) and Minnesota (Mech et al. 1988). The wolf then officially became a wilderness animal, and road densities became the yardstick by which wolf habitat suitability was measured by agencies and recovery teams.

Wolf Recovery

As more was learned about the wolf, the increasingly urbanized public continued to favor wolf recovery. Even though illegal taking of wolves persists in local areas of North America and Europe, it has not been sufficient to prevent wolf population growth. In Minnesota, some 75% of the public viewed the wolf favorably (Kellert 1986), a statistic that may be mirrored in much of the northern hemisphere.

Minnesota's wolf population, now probably about 2000 based on trend estimates by Fuller et al. (1992), proliferated into neighboring Wisconsin and Michigan (Thiel 1978; Mech et al. 1995*b*), where they currently number over 100 (Mech et al. 1995*a*). Other Minnesota wolves eventually spread into the Dakotas (Licht & Fritts 1994). Canadian wolves were no longer killed when they reached Montana, and they began to recolonize the Glacier National Park area (Ream & Mattson 1982). One pair even raised pups among a herd of cattle on the prairies of the Rockies' eastern front (Diamond 1994). Montana now supports an estimated 70 wolves, and additional animals from Canada are entering Idaho and Washington state (Mech et al. 1995*a*).

Europe has seen the same trend. In Italy the wolf population responded to the protection resulting from the research and educational effort of Boitani (1986) and increased to 300 individuals that inhabit even areas around the outskirts of Rome. In Spain wolf numbers reached 1500–2000 (Blanco et al. 1990), and in Poland about 850 (Bobek et al. 1993). Overflow from the former Soviet Union allowed a population of about 50 to develop in Finland (Pulliainen 1993), and eventually a nascent population developed that straddles Norway and Sweden, currently numbering 20–25 (Promberger et al. 1993*a*). Wolves are also spreading from northern Italy into France and from Poland into eastern Germany (Promberger et al. 1993*b*).

The much-improved public attitude toward wolves, coupled with publicity and law enforcement, have allowed the burgeoning wolf populations to use areas that had not been wolf habitat for decades, thus demonstrating the wolf's inherent adaptability. The wolf's new range includes areas of higher road density (Fuller et al. 1992) and much more open, accessible, and populated areas. Breeding packs now live less than 90 km from Minneapolis and St. Paul, Minnesota. One wolf was radio-tracked out of the forests in which it had been raised and into farm fields within 30 km of St. Paul's center (Wydeven 1994). The animal roamed the farmlands for several weeks before returning to forest. Other wolves making their way south of Minneapolis and St. Paul are being killed by cars or shot when mistaken for coyotes (*Canis latrans*). Wolves dispersing into North and South Dakota have been crossing great expanses of open areas (Licht & Fritts 1994).

In Spain wolves live like coyotes in wheat and sunflower fields in regions with human densities of up to 200 people per km^2 (Vila et al. 1993). The animals scavenge garbage and livestock remains and hunt smaller mammals. In Canada, Alaska, Scandinavia, the Mideast, and much of Asia, wolf numbers are stable or increasing (Ginberg & Macdonald 1990).

Given protection, wolves can expand their range rapidly (Fuller et al. 1992). Average litter sizes reach five to six (Mech 1970). The territorial packs produce young each year, and maturing individuals disperse (Fritts & Mech 1981; Gese & Mech 1991) distances that may exceed 800 km straightline (Fritts 1983). They search out mates and begin new packs (Rothman & Mech 1979) in new areas (Ream et al. 1991).

As wolves dispersed from wildernesses, they successfully contended with highways, traffic, residences, habitat fragmentation, and other human disturbances (Mech et al. unpublished data). Some probably were unable to adapt, especially the first waves. Nevertheless, wolves that did settle semiwilderness areas probably be-

came more habituated to the increased disturbances, and as a population then adapted more to increasing disturbance.

In Italy, Spain, and Portugal, where much of the wolf's food is comprised of garbage, wolves have long inhabited the wooded mountains during the day and made their way into rural villages to scavenge at night (Zimen & Boitani 1979). In North America, ungulate population densities are high close to population centers. Thus, wolves have plentiful natural prey when they move to new, nonwilderness areas.

As wolves show up in new regions they gather new constituencies that support their recovery. In Europe the European Wolf Network dedicated to the recovery of the wolf in central Europe (Promberger & Schroder 1993) became a branch of the IUCN Wolf Specialist Group in 1992. Other organizations have formed in North America that call for the reintroduction of wolves into such places as Arizona, Colorado, northern New York, and New England.

Problems of Wolf Recovery

As wolves move into agricultural areas, conflicts with humans greatly increase. For example, when Minnesota wolves increased from 1988 through 1993 by an estimated 15%, the number of wolves killed by the U.S Department of Agriculture Animal Damage Control Program increased from 59 to 139, or 223% (Paul 1994). In Spain, estimated damage by wolves now exceeds $1 million per year (Vila et al. 1993).

With these conflicts comes a distinct danger of public backlash. Not only will wolves in semi-agricultural areas take increasing numbers of livestock and incur the wrath of the livestock industry, which often has strong political support, but they will also kill pets. In Minnesota, wolves killing dogs has caused considerable public animosity (Fritts & Paul 1989). As the media begins publicizing such issues, the public gains an exaggerated impression of the problem. A strong backlash of antiwolf sentiment could result in management practices that would again restrict wolves to wilderness areas. Poland has experienced three such cycles of wolf protection and persecution (Okarma 1992). How can these problems be avoided and the wolf be restored to as many places as possible? Until some nonlethal method of controlling wolf populations is discovered, it appears that lethal control will remain the ultimate means of curbing wolf damage to livestock and pets.

Several nonlethal methods of preventing livestock losses to wolves have been tried and abandoned. In Italy and other European countries, for example, traditional husbandry techniques relied on guard dogs and shepherds tending small flocks of livestock; such techniques today are uneconomical. Use of guard dogs alone has been tried against wolves in Minnesota with only limited success (Fritts et al. 1992), although the method may be useful in specific cases. Wolves have also been translocated to other areas, but many either returned to where they were caught or became a problem elsewhere (Fritts et al. 1984, 1985). Aversive conditioning (Gustavson & Nicolaus 1987) has not yet proven effective with wild wolves (Fritts et al. 1992). Currently an electric fence in use in Sweden seems to hold some promise for protecting livestock from wolves, but it has not yet been subject to controlled testing (Eles 1986). Furthermore, such fences tested for coyotes have generally been expensive, high-maintenance, and better suited for smaller areas (Dorrance & Bourne 1980; Nass & Theade 1988).

Compensation for livestock losses is useful for minimizing public animosity toward wolves, especially when wolf populations are low and each wolf is important to the population. In Italy, compensation was important in changing public attitudes toward acceptance of wolves in agricultural areas. But as wolf populations proliferate, compensation payments must also increase, sometimes disproportionately. At some point compensation payments will become politically unpopular as the public learns it is subsidizing wolves via payments to farmers for their wolf-killed livestock. Thus many government agencies are wary of even initiating such payments.

An innovative alternative to public payment for livestock killed by wolves was instituted by the Defenders of Wildlife in the U.S. This private, nonprofit organization established a fund to reimburse ranchers in the western U.S. and even encouraged ranchers to allow wolves to raise pups on their private land via a payment of $5000 per den (Fischer et al. 1994). The public may well begin demanding that animal organizations assume these burdens from the government as the costs increase. In any case, without wolf population control, people would eventually object to payments or damages caused by wolves.

Wolf Management Zoning

With natural habitat in so many areas greatly fragmented and wolves adapting to travel through relatively settled and open areas, some disjunct wolf populations are developing where wolves can live without causing livestock damages. For example, about 90 km northwest of Minneapolis and St. Paul, Minnesota, a pack has lived and bred for at least two years on a wildlife management area surrounded by agricultural land without killing local livestock. Similar instances are known in Montana (Diamond 1994) and other parts of Minnesota (Fritts & Mech 1981; Fritts et al. 1992). This suggests that management zoning could allow wolves to inhabit areas where they can feed on natural prey while they are kept out of agricultural areas.

The approach is to designate zones of potential wolf habitat and distinguish them from areas that should be kept wolf-free. Zoning is common in regulating wildlife harvesting and has been applied on a large scale in wolf recovery plans (U.S. Fish and Wildlife Service 1975, 1987). If public attitudes continue to lean toward protectionism, pressure may develop to apply zoning on local levels such that small sanctuaries are maintained and control is applied only outside these areas.

The scale of zoning is important. Wolves could be zoned out of entire states or zoned into only large national parks or nature preserves. Or they could be allowed to inhabit any area they naturally colonize as long as their sole prey is wild species. For example, in a wildlife refuge of only 100 km^2 surrounded by farmland including livestock, wolves could be protected in the refuge but destroyed immediately outside it. This is similar to the situation in Riding Mountain National Park, Manitoba, which, although a much larger area, is an island of wilderness in a sea of agricultural land (Carbyn 1982).

The main advantage of large-scale zoning is simplification and efficiency of management. Any wolf in a designated no-wolf state or outside any large wolf refuge would be subject to legal taking, while those inside would be protected or managed through regulated taking. This scenario could allow wolf populations to remain in the Lake Superior states and much of the mountainous regions of the western U.S., depending on how large the zones are.

The main disadvantage of large-scale zoning is the need to protect livestock that would inevitably live inside some of the larger zones. In Minnesota this would perpetuate the current situation in which close to 150 wolves are killed by government controllers annually for about $1225 each. A second disadvantage is that wolves would probably not be allowed in many areas where they really could live. This might mean banishing wolves from the state wildlife area mentioned above where one to two packs have been living without causing livestock depredations. Furthermore, in most of Europe where there are few if any large, remote regions left, large-scale zoning would be very difficult.

With small-scale zoning the main disadvantage for management agencies is complexity. At one extreme even single wolf packs in areas without livestock would be protected, while immediately outside wolves could be taken. This could present difficult law-enforcement problems, although such problems are not unlike those that currently exist for other species in wildlife refuges, national parks, and other protected areas. A small-scale zoning proposal in Italy (Boitani & Fabbri 1983) was opposed by wolf protectionists because of the difficulty of law enforcement and the feeling that wolves would be relegated to areas too small to maintain viable populations.

Such a fine-grained approach would probably require management agencies to identify possible wolf areas so that when colonized they would be recognized as wolf sanctuaries. Geographic information systems would greatly simplify this task. Furthermore, identification of such sanctuaries could be incorporated into ecosystem management plans, biodiversity initiatives, and similar strategies as they are developed for other reasons.

The main advantage of small-scale zoning would be to allow wolves to live in enclaves throughout much of Europe and the United States, similar to the way they currently inhabit Wisconsin and Michigan (Hammill 1993; Wydeven et al. 1994). For several reasons, this approach would not require the very large-scale land and habitat protection visualized by the Wildlands Project (Mann & Plummer 1993). Although dispersing wolves would be subject to persecution while passing through nonprotected areas, those moving primarily at night or outside of hunting seasons would stand a reasonable chance of survival. With enough small enclaves of wolves, there should be large numbers of such dispersers to colonize new areas, resupply reduced populations, provide sufficient outbreeding, and thus comprise regional metapopulations. Furthermore, inbreeding depression, while a problem among some captive wolves (Laikre & Ryman 1991), probably is not in most wild populations because of the high natural turnover and ensuing selection. Deleterious alleles should get cleansed from the population quickly.

The Isle Royale wolf population is instructive. Isle Royale is a 538-km^2 national park in Lake Superior some 25 km from Ontario. It was colonized by wolves about 1949 (Mech 1966), probably by only two unrelated wolves (Rothman & Mech 1979). Genetic testing after 40 years indicated a single female founder (Wayne et al. 1991). Nevertheless, the population stabilized at about 23 for a long period and increased to 50 in 1980, the highest wolf density on record (Peterson & Page 1988). Although the population then crashed, raising concerns about inbreeding depression and disease (Peterson & Krumenaker 1989), the wolves survive. In 1994, eight 1993 offspring survived (Peterson 1994). Thus, with just two founders and 50% loss of genetic variability (Wayne et al. 1991), this population has survived for 45 years. Had it been on the mainland, chances are good that some outbreeding would have occurred.

Biologically, wolves could inhabit parts of almost all regions of the U.S. and many European countries. Since protection, they have been recorded in nine and possibly ten U.S. states. If biology were the only relevant factor, however, wolves would never have had to be declared endangered. Throughout the wolf's former range, it has been persecuted because of its tendency to prey on livestock and pets. Even though it is currently on the endangered species list in the U.S., control has been applied in Minnesota, Wisconsin, and Mon-

tana. Thus there is every reason to believe that wolf control will parallel wolf recovery wherever it takes place (Mech 1979; Fritts 1993).

The Dilemma of Wolf Management

The inevitability of wolf control, however, introduces a new, complex element into the equation governing the wolf's future in all but the remotest areas of the world: wolf protectionism. The same cultural attitudes that fostered wolf recovery also encouraged an extreme degree of wolf protectionism. Those of us professionally involved with wolf recovery have traditionally been maligned by antiwolf people (Haubner 1990). Now we are vilified by many wolf lovers as wolf enemies because of our acknowledgment that wolves often require control.

Wolves are revered for several reasons. Because they tend to kill prey that are old, sick, or weak (Murie 1994; Mech 1970), many laypeople mistakenly believe that, without wolves, prey would automatically die out from disease. Wolves are also hailed as good models for the human race because of their alleged monogamy and family allegiances. A book has even been written titled *The Soul of the Wolf* (Fox 1980).

Other misconceptions about wolves encourage wolf protectionism. Because of the book *Never Cry Wolf* by Farley Mowat (1963) and the popular movie made from the book, many people believe wolves live primarily on mice rather than ungulates. Both are fiction (Banfield 1964; Pimlott 1966), but both purport to be true and are sold and shown by museums and other unsuspecting educational organizations. Other misconceptions, half truths, and outdated views that many protectionists hold include the following: wolves only prey on livestock when no natural prey is available; the loss of pack members fosters disastrous social chaos in the wolf population; wolves socially limit their own population; because the wolf is on the U.S. endangered species list, this means that there are very few left anywhere in the world; and wolves are so shy of humans that they will move out of areas of high activity or avoid settling in them, and they will maintain dens and pups only many kilometers from such activity.

Because of these misconceptions and the power of animal rights groups, wolf control is resisted by much of the public (see Garrott et al. 1993). This attitude has three major negative implications for wolf recovery. First, some people revere wolves so much that, rather than having wolves face control, these people would rather not restore wolves to areas where they would have to be controlled. Because wolves will probably have to be controlled almost everywhere they are restored, this sentiment translates into political pressure against wolf recovery. Second, the antiwolf public, such as some livestock owners and organizations, intensify their antiwolf attitudes in reaction to the extremism of the other side. They also fear the possibility of road closures and other restrictions on land use that are often fostered by protectionists using the wolf to prevent logging, mining, snowmobiling, or other human uses of semiwilderness and wilderness. Third, some wolf advocates resort to terrorism (Hayes, personal communication) and deceptive advertisements (Anonymous 1992). This zealotry intimidates public officials, who might otherwise be predisposed toward wolf recovery, to shun it.

Of course, the prowolf contingent holds a wide spectrum of attitudes. Thus, some people will accept control against livestock depredations but oppose control prescribed for increasing game herds. Some will accept control by government agencies but not by the public. Many people will accept indirect methods of control such as fencing, guard dogs, or aversive conditioning. These indirect methods are more acceptable because they do not involve humans killing wolves directly. Few proponents of these methods seem to realize, however, that keeping wolves from prey ultimately reduces the carrying capacity of wolf range, and thus fosters starvation and increased deaths from intraspecific strife (Mech 1994). This is particularly true in countries such as Italy, Spain, Israel, where a high percentage of the total carrying capacity for wolves is comprised of livestock, but it applies on a smaller scale to North America as well. As long as wolf deaths are either indirect (and thus not so obvious) or natural, many people accept these deaths who would not tolerate direct or human-caused deaths.

Direct lethal control is still usually the only practical course under most conditions. There are several ways to apply this control. Control by government agency, usually the Department of Agriculture in the U.S., is the type generally most acceptable to wolf advocates, but it is by far the most expensive and time-consuming. Control by landowners or their agents is the one most favored by landowners, but it is difficult to police, and most landowners lack the time and expertise for it, except by poisoning. Open taking of wolves year-round in no-wolf zones similar to the taking of coyotes in most areas of the U.S., and regulated taking by the public, could be applied in no-wolf zones or in wolf sanctuaries to hold the population down such as is done in many suburban areas for white-tailed deer (*Odocoileus virginianus*), geese (*Anser* sp.), and beavers. A modification of this type of control is public taking by special permit.

All of the nongovernment approaches to control are much less expensive but also less precise to the area or to specific wolves taken and generally are the most disliked by wolf advocates. A notable exception is the government control of wolves to increase herds of big game in areas of Alaska and Canada. A public take of 1200–1500 wolves per year in Alaska brings little or no protest, but the state's controlling of 150 wolves to increase

big game herds is protested vehemently (Anonymous 1993). While biologically this seems illogical, politically such state control allows animal-rights groups to portray this control as a dastardly government program that must be stopped.

The wolf's high reproductive potential and its tendency to disperse hundreds of kilometers insure that there are few places where wolves could be restored without some form of control being necessary. But the very people most enthusiastically promoting wolf recovery are generally those who want no control, so this dilemma makes public officials reluctant to promote recovery.

Because wolf-taking by landowners or the public is the least expensive and most acceptable to people who do not regard the wolf as special, there will be greater local acceptance for wolf recovery in areas where such control is allowed. Thus, if wolf advocates could accept effective control, wolves could live in far more places.

The Need for Public Education

It appears that the best way to promote wolf recovery is to encourage public education about wolf management issues so that a significant proportion of the public would support wolf recovery while tolerating some form of control. Public education programs must include the message that any restoration of wolves will ultimately result in a need to control them (Fritts et al. in press). Of course, there will always be animal-rights advocates who never will accept any wolf control. If their views are seen by most of the public as counterproductive to wolf recovery, however, officials can probably be persuaded to allow wolves to live in far more of their former range.

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Literature Cited

Allen, D. L., and L. D. Mech. 1963. Wolves versus moose on Isle Royale. National Geographic **123(2)**:200–219.

Anonymous. 1992. Vaguely worded ads force Alaska to delay wolf kill. Star Tribune, December 22:20A.

Anonymous. 1993. Alaska wolf plan defeated by communication failures. International Wolf **3(2)**:10–15.

Banfield, A. W. F. 1964. Review of F. Mowat's Never Cry Wolf. Canadian Field Naturalist **78**:52–54.

Blanco, J. C., L. Cuesta, and S. Reig, editors. 1990. El lobo (*Canis Lupus*) en Espana situacion, problematica y apuntes sobre su ecologia. Ministero de Agricultura Pesca y Alimentacion, Icona, Publicaciones del Instituto Nacional para la Conservacion de la Naturaleza, Madrid.

Bobek, B., M. Kosobucka, K. Perzanowski, K. Plodzien. 1993. Distribution and wolf numbers in Poland. Pages 26–29 in C. Promberger and W. Schroeder, editors. Wolves in Europe: Status and perspectives. Proceedings of Wolves in Europe—current status and prospects. Munich Wildlife Society, Ettal, Germany.

Boitani, L. 1986. Dalla parte del lupu. L'Airone di Giorgio Mondadori e Associati Spa, Milano, Italy.

Boitani, L., and M. L. Fabbri. 1983. Strategia nationale di conservationi per il lupo. Ricerche di Biologia della Selvaggina **72**:1–31.

Carbyn, L. N. 1982. Incidence of disease and its potential role in the population dynamics of wolves in Riding Mountain National Park Manitoba. Pages 106–116 in F. H. Harrington and P. C. Paquet, editors. Wolves of the world: Perspectives of behavior, ecology and conservation. Noyes Publications, Park Ridge, New Jersey.

Cochran, W. W., and R. D. Lord, Jr. 1963. A radio-tracking system for wild animals. Journal of Wildlife Management **27**:9–24.

Delibes, M. 1990. Status and conservation needs of the wolf (*Canis lupus*) in the Council of Europe member states. Nature and Environment Series 47. Council of Europe, Strasbourg, France.

Diamond, S. 1994. The prairie wolf returns. International Wolf **4(1)**: 3–7.

Dorrance, M. J., and J. Bourne. 1980. An evaluation of anti-coyote electric fencing. Journal of Range Management **33**:385–387.

Eles, H. 1986. Vargen. Arsbok fran Varmlands Museum, Argang 84. Andra upplagan, AB Ystads Centraltryckeri 74013, Sweden.

Fischer, H., B. Snape, and W. Hudson. 1994. Building economic incentive into the Endangered Species Act. Endangered Species Technical Bulletin **19(2)**:4–5.

Fox, M. W. 1980. The soul of the wolf. Little, Brown and Company, Boston.

Fritts, S. H. 1983. Record dispersal by a wolf from Minnesota. Journal of Mammalogy **64**:166–167.

Fritts, S. H. 1993. Controlling wolves in the greater Yellowstone area. Pages 173–233 in Robert S. Cook, editor. Ecological issues on reintroducing wolves into Yellowstone National Park. Scientific Monograph NPS/NRYELL/ NRSM-93/22. U.S. National Park Service, Washington, D.C.

Fritts, S. H., and L. D. Mech. 1981. Dynamics, movements, and feeding ecology of a newly protected wolf population in northwestern Minnesota. Wildlife Monographs 80.

Fritts, S. H., and W. J. Paul. 1989. Interactions of wolves and dogs in Minnesota. Wildlife Society Bulletin **17**:121–123.

Fritts, S. H., W. J. Paul, and L. D. Mech. 1984. Movements of translocated wolves in Minnesota. Journal of Wildlife Management **48**:709–721.

Fritts, S. H., W. J. Paul, and L. D. Mech. 1985. Can relocated wolves survive? Wildlife Society Bulletin **13**:459–463.

Fritts, S. H., W. J. Paul, L. D. Mech, and D. P. Scott. 1992. Trends and management of wolf-livestock conflicts in Minnesota. Resource Publication 181. U.S. Fish and Wildlife Service, Washington, D.C.

Fritts, S. H., E. E. Bangs, J. A. Fontaine, W. G. Brewster, and J. F. Gore. In press. Restoring wolves to the northern Rocky Mountains of the United States. In L. D. Carbyn, S. H. Fritts, and D. R. Seip, editors. Ecology and conservation of wolves in a changing world. Canadian Circumpolar Institute, Edmonton, Alberta.

Fuller, T. K. 1989. Population dynamics of wolves in north central Minnesota. Wildlife Monographs **105**:1–41.

Fuller, T. K., W. E. Berg, G. L. Radde, M. S. Lenarz, and G. B. Joselyn. 1992. A history and current estimate of wolf distribution and numbers in Minnesota. Wildlife Society Bulletin **20**:42–55.

Garrott, R. A., P. J. White, and C. A. Vanderbilt White. 1993. Overabundance: An issue for conservation biology. Conservation Biology 7:946–949.

Gese, E. M., and L. D. Mech. 1991. Dispersal of wolves (*Canis lupus*) in northeastern Minnesota, 1969–1989. Canadian Journal of Zoology 69:2946–2955.

Ginsberg, J. R., and D. W. Macdonald. 1990. Foxes, wolves, jackals, and dogs. World Conservation Union, Gland, Switzerland.

Gustavson, C. R., and L. K. Nicolaus. 1987. Taste aversion conditioning in wolves, coyotes and other canids: Retrospect and prospect. Pages 169–200 in H. Frank, editor. Man and wolf: Advances, issues, and problems in captive wolf research. Dr. W. Junk Publishers, Dordrect, The Netherlands.

Hammill, J. 1993. Wolves in Michigan: A historical perspective. International Wolf 3(1):22–23.

Haubner, M. H. 1990. Our wildlife crisis—the wolf saga. Nancy Finberg, Carlton, Minnesota.

Jensen, W. F., T. K. Fuller, and W. L. Robinson. 1986. Wolf (*Canis lupus*) distribution on the Ontario-Michigan border near Sault Ste. Marie. Canadian Field Naturalist 100:363–366.

Kellert, S. R. 1986. The public and the timber wolf in Minnesota. Pages 193–200 in R. E. McCabe, editor. Transactions of North American Wildlife and Natural Resource Conference, vol. 51. Reno, Nevada.

Kolenosky, G. B., and D. H. Johnston. 1967. Radio-tracking timber wolves in Ontario. American Zoologist 7:289–303.

Laikre, L., and N. Ryman. 1991. Inbreeding depression in a captive wolf (*Canis lupus*) population. Conservation Biology 5:33–40.

Licht, D. S., and S. H. Fritts. 1994. Gray wolf (*Canis lupus*) occurrences in the Dakotas. American Midland Naturalist 132(1):74–81.

Mann, C. C., and M. L. Plummer. 1993. The high cost of biodiversity. Science 260:1868–1871.

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

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

Mech, L. D. 1977. Productivity, mortality and population trends of wolves in northeastern Minnesota. Journal of Mammalogy 58:559–574.

Mech, L. D. 1979. Some considerations in re-establishing wolves in the wild. Pages 445–457 in E. Klinghammer, editor. The behavior and ecology of wolves. Garland STPM Press, New York.

Mech, L. D. 1994. Buffer zones of territories of gray wolves as regions of intraspecific strife. Journal of Mammalogy 75:199–202.

Mech, L. D., and L. D. Frenzel, Jr. 1971. Ecological studies of the timber wolf in northeastern Minnesota. U.S. Department of Agriculture Forest Service Research Paper NC–52. North Central Forest Experiment Station, St. Paul, Minnesota.

Mech, L. D., S. H. Fritts, G. Radde, and W. J. Paul. 1988. Wolf distribution in Minnesota relative to road density. Wildlife Society Bulletin 16:85–88.

Mech, L. D., D. H. Pletscher, and C. J. Martinka. 1995*a*. Gray wolf status and trends in the contiguous United States. In E. T. LaRoe, G. S. Farris, C. E. Puckett, and P. D. Doran, editors. Our living resources 1994: A report to the nation on distribution, abundance and health of U.S. plants, animals, and ecosystems. National Biological Survey, Washington, D.C.

Mech, L. D., S. H. Fritts, and D. Wagner. 1995*b*. Minnesota wolf dispersal to Wisconsin and Michigan. American Midland Naturalist 133(2), in press.

Mowat, F. 1963. Never cry wolf. Dell Publishing Company, New York.

Murie, A. 1944. The wolves of Mt. McKinley. Fauna Series 5. U.S. National Park Service, Washington, D.C.

Nass, R. D., and J. Theade. 1988. Electric fences for reducing sheep losses to predators. Journal of Range Management 41:251–252.

Okarma, H. 1992. Wilk in Poland. Polish Academy of Sciences, Mammal Research Institute, Bialowieza, Poland.

Paul, W. J. 1994. Wolf depredation on livestock in Minnesota annual update of statistics—1993. U.S. Animal and Plant Health Inspection Service, Animal Damage Control, Grand Rapids, Minnesota.

Peterson, R. O. 1994. Out of the doldrums for Isle Royale wolves? International Wolf 4(2):19.

Peterson, R. O., and R. E. Page. 1988. The rise and fall of the Isle Royale wolves. Journal of Mammalogy 69:89–99.

Peterson, R. O., and R. J. Krumenaker. 1989. Wolves approach extinction on Isle Royale: A biological and policy conundrum. George Wright Forum 6:10–15.

Pimlott, D. H. 1966. Review of F. Mowat's *Never Cry Wolf*. Journal of Wildlife Management 30:236–37.

Pimlott, D. H., editor. 1975. Wolves. Proceedings of the first working meeting of wolf specialists and of the first international conference on the conservation of the wolf. International Union for Conservation of Nature and Natural Resources, Morges, Switzerland.

Promberger, C., and D. I. Bibikov. 1993. The wolf in the Community of Independent States (former Soviet Union). Pages 23–24 in C. Promberger and W. Schroder, editors. Wolves in Europe: Status and perspectives. Munich Wildlife Society, Ettal, Germany.

Promberger, C., and W. Schroder, editors. 1993. Wolves in Europe: Status and perspectives. Munich Wildlife Society, Ettal, Germany.

Promberger, C., and M. Dahlstrom, U. Wotschikowsky, E. Zimen, and P. Wabbakken. 1993*a*. Wolves in Sweden and Norway. Pages 8–13 in C. Promberger and W. Schroder, editors. Wolves in Europe: Status and perspectives. Munich Wildlife Society, Ettal, Germany.

Promberger, C., C. Vogel, and M. Von Loeper. 1993*b*. Wolves in Germany. Pages 30–34 in C. Promberger and W. Schroder, editors. Wolves in Europe: Status and perspectives. Munich Wildlife Society, Ettal, Germany.

Pulliainen, E. 1993. The wolf in Finland. Pages 14–20 in C. Promberger and W. Schroder, editors. Wolves in Europe: Status and perspectives. Munich Wildlife Society, Ettal, Germany.

Ream, R. R., and U. I. Mattson. 1982. Wolf status in the Northern Rockies. Pages 362–381 in F. H. Harrington and P. C. Paquet, editors. Wolves of the world: Perspectives of behavior, ecology and conservation. Noyes Publications, Park Ridge, New Jersey.

Ream, R. R., M. W. Fairchild, D. K. Boyd, and D. H. Pletscher. 1991. Population dynamics and home range changes in a colonizing wolf population. Pages 349–366 in R. B. Keiter and M. S. Boyce, editors. The Greater Yellowstone ecosystem, redefining America's wilderness heritage. Yale University Press, New Haven, Connecticut.

Rothman, R. J., and L. D. Mech. 1979. Scent-marking in lone wolves and newly formed pairs. Animal Behavior 27:750–760.

Theberge, J. B. 1975. Wolves and wilderness. J. M. Dent and Sons, Toronto, Canada.

Thiel, R. P. 1978. The status of the timber wolf in Wisconsin 1975. Transactions Wisconsin Academy Science, Arts, and Letters 66:186–194.

Thiel, R. P. 1985. Relationship between road densities and wolf habitat suitability in Wisconsin. American Midland Naturalist 113:404–407.

U.S. Fish and Wildlife Service. 1975. Recovery plan for the eastern timber wolf. USFWS, Twin Cities, Minnesota.

U.S. Fish and Wildlife Service. 1982*a*. Mexican wolf recovery plan. USFWS, Albuquerque, New Mexico.

U.S. Fish and Wildlife Service. 1982*b*. Red wolf recovery plan. USFWS, Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1987. North Rocky Mountain wolf recovery plan. USFWS, Denver, Colorado.

Vila, C., J. Castroviejo, and V. Urios. 1993. The Iberian wolf in Spain. Pages 104–109 in C. Promberger and W. Schroder, editors. Wolves

in Europe: Status and perspectives. Munich Wildlife Society, Ettal, Germany.

Wayne, R. K., D. A. Gilbert, N. Lehman, K. Hansen, A. Eisenhawer, D. Girman, L. D. Mech, P. J. P. Gogan, U. S. Seal, and R. J. Krumenaker. 1991. Conservation genetics of the endangered Isle Royale gray wolf. Conservation Biology 5:41–51.

Wydeven, A. P. 1994*a*. Travels of a Midwestern disperser. International Wolf 4(1):20–22.

Wydeven, A. P., R. N. Schultz, and R. P. Thiel. 1994. Gray wolf monitoring in Wisconsin. L. D. Carolyn, S. H. Fritts, and D. R. Seip, editors. Ecology and conservation of wolves in a changing world. Canadian Circumpolar Institute, Edmonton, Alberta.

Young, S. P., and E. A. Goldman, editors. 1944. The wolves of North America. American Wildlife Institute, Washington, D.C., and Dover Publishers, New York.

Zimen, E. 1981. The wolf: A species in danger. Delacourt, New York.

Zimen, E., and L. Boitani. 1979. Status of the wolf in Europe and the possibilities of conservation and reintroduction. Pages 43–83 in E. Klinghammer, editor. The behavior and ecology of wolves. Garland STPM Press, New York.