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Wolves in Utah: An analysis of potential impacts and recommendations for management

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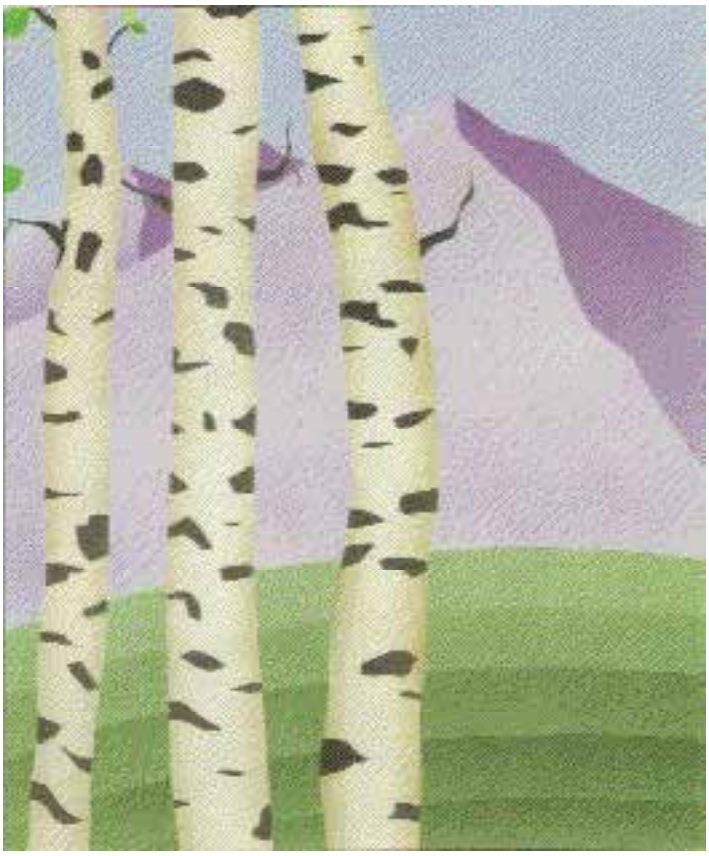
Wolves in Utah: An Analysis of Potential Impacts and Recommendations for Management



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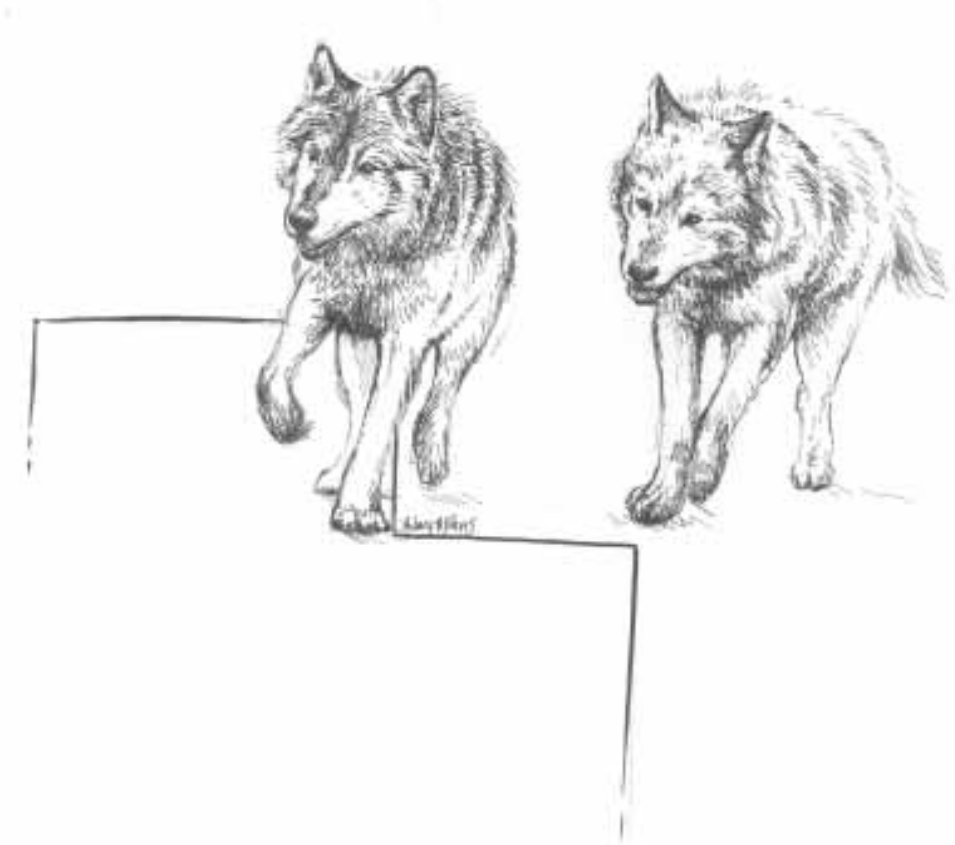

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October 2002

The College of Natural Resources is a leader in the discovery, innovation, and lifelong learning that promotes the healthy ecosystems upon which human communities depend. To accomplish this vision, the College provides undergraduate and graduate education programs, conducts research, and sponsors extension education programs on natural resource and environmental issues. We put a great deal of emphasis on integrating biological, ecological, physical, geographic, and social sciences in our work, which reaches and impacts all comers of the state, the country, and indeed the world.

This report, *Wolves in Utah: an analysis of potential impacts and recommendations for management,* is the product of a College of Natural Resources course in natural resource policy. Graduate students, undergraduate students, and faculty were all involved in its development, but our students conducted the bulk of the work. Wolf management programs and strategies in Utah will be contentious, and the citizens of Utah deserve access to research- based information. This report brings together many legal, social, economic, and biological issues central to the development of any Utah wolf management plan. It makes specific predictions about the impacts of wolves in this state, and outlines areas that are in critical need of additional analyses. It does not advocate for wolf reintroduction. It does not set a date for the occurrence of wolves in Utah, nor does it outline the mechanism for recolonization. As the reports states, “We attempt to put the issues on the table, and we encourage full and thorough debate on all aspects of wolf management. The needs and wishes of all Utahns, the preservation of Utah's wild environments, and the legacy we leave to future generations require nothing less.”

As I stated above, this College is committed to the healthy ecosystems upon which human communities depend. In the future, these ecosystems may include wolves. This report provides a starting point for the necessary discussions on how Utah's wolves might be managed.

Sincerely,

F.E. “Fee” Busby,
Dean, College of Natural Resources
Utah State University

COLLEGE OF NATURAL RESOURCES

Executive Summary

The historic range of gray wolves (*Canis lupus*) in Utah was essentially statewide. Although their presence cannot be disputed, the historic abundance of wolves in Utah is unknown. The release of gray wolves into Yellowstone National Park and central Idaho in 1995 established growing populations, and increasing dispersal is bringing these wolves closer to Utah. It seems likely that wolves will commingle with Utah's other native mammals in the near future. The potential presence of wolves in Utah is generating a series of questions and debates. In this report, we review the potential of wolves in Utah and make predictions regarding the social and economic impacts of wolf recolonization on the livestock industry, on hunter success, and on wildlife managers, and then make recommendations on possible ways to mitigate these impacts.

The United States Fish and Wildlife Service (USFWS) classifies gray wolf populations as either *endangered, threatened,* or *nonessential/experimental*. In the short term, it is likely that the USFWS will "downlist" wolves from endangered to threatened status. Once a wildlife species is removed from the endangered or threatened list, it becomes the responsibility of the states in which it occurs. Therefore, when wolves are de-listed, the state of Utah will assume the responsibility for managing any wolves in the state. There is an alternative scenario, in which de-listing of the wolf in the northern Rockies would not necessarily lead to de-listing in Utah. A number of nongovernmental organizations are currently petitioning the USFWS to create a Distinct Population Segment in the southern Rockies, an area that would include Colorado, Utah, and northern New Mexico. Under this scenario, wolves could remain endangered in Utah, even if they were de-listed in the northern Rockies.

La Vine (1995) conducted a survey of 707 Utah residents and public land-grazing permittees regarding their attitudes toward wolves. Although a majority of Utah residents held either positive or neutral attitudes toward wolves, those who held permits to graze cattle and sheep on public lands within the state expressed negative attitudes toward wolves. In contrast, big-game hunters were rather evenly divided. While Utahns as a whole were generally in favor of wolves, with the exception of permittees, approval of wolves differed between nonmetropolitan and metropolitan areas. This pattern is consistent with findings in other areas, where those most likely to be directly affected by potential wolf recovery (i.e, rural residents) tend to display the most negative attitudes. Utah has a unique social climate in comparison with the surrounding states, but consideration of other attitude studies hints that as wolves gain a foothold in the state, attitudes may shift.

Dispersing wolves can travel hundreds of kilometers in search of potential mates. If wolves in the northern Rockies are allowed to expand their population, dispersal outside of the Greater Yellowstone Ecosystem (GYE) will be inevitable. Some wolves will travel south toward Utah. Geographic Information Systems (GIS) analysis has shown high connectivity of intact habitat between the GYE and both the Bear River Range of northern Utah and Flaming Gorge National Recreation Area. Despite these avenues for

possible dispersal, a number of human factors may prevent wolves from establishing a viable population in Utah.

We have identified areas in Utah where dispersing wolves are most likely to colonize. Our habitat model shows that most of forested, mountainous Utah, an area of more than 36,000 km^2, has the potential for wolf recolonization. However, because of high road densities, our model scored many parts of these areas as marginal wolf habitat, resulting in a substantial degree of fragmentation. Despite this fragmentation, a number of relatively large, contiguous areas of high-quality habitat can be identified from this map. Additionally, we calculated that Utah could, in theory, support approximately 700 wolves distributed throughout the state. However, core habitat areas may only support approximately 200 wolves.

Wolves are a top-level predator whose presence is an indicator of an ecosystem's integrity. The degree to which wolves may either regulate or limit prey populations remains controversial. Typically, wolves do not appear to dramatically reduce prey populations. Rather, wolf predation appears to generally dampen fluctuations in prey numbers. One reason for this may be that wolves generally seize upon the most vulnerable prey (e.g., young, old, sick, and injured), which are the easiest animals to catch and kill. Severe weather appears to be the primary limiting factor for ungulate populations in Yellowstone, Minnesota, and Wisconsin.

Although the literature suggests that recolonizing wolves will probably have a small effect on the dynamics of Utah's ungulate populations, they may exhibit a greater influence through changes in ungulate behavior and cascading effects. Although the Yellowstone elk herds have remained very stable throughout wolf recovery, elk may be shifting their habitat use away from high wolf-use riparian areas. Large areas of riparian willow have begun to recover from overgrazing by elk. Additionally, wolf recovery may aid in the restoration of aspen groves.

Wolf reintroduction and recovery in other areas has changed the abundance and distribution of many predators and scavengers. Through direct predation, wolves reintroduced into Yellowstone have reduced the coyote population. Since reintroduction, scavengers have benefited greatly from the consistent year-round supply of wolf-killed ungulates. Preliminary findings show that grizzly bears, coyotes, foxes, ravens, magpies, bald eagles, and golden eagles are all using wolf-killed carcasses, and anecdotal evidence suggests that populations of many of these species are increasing (with the exception of coyotes).

The potential economic benefits from wolf recovery include both use values such as increases in tourism resulting from the presence of wolves and non-use values that can be measured by willingness to pay surveys. The expected costs of recovery include direct costs born by agencies involved in wolf management and livestock owners who experience losses from wolf depredations. There are also potential direct costs, such as those that might result from reduced game take by hunters. In addition, there may be indirect costs, which are more difficult to quantify.

We based our estimates of the potential economic impact of wolves on the presence of 200 wolves in the state, and used actual costs from other areas that currently support wolf populations. We estimate that total wolf management costs should never exceed $130,000 per year. We also estimate that, on average, between 9 and 19 wolves would be controlled annually in Utah. We would expect very few depredations (averaging < 2 annually) on adult cattle in Utah, corresponding to an annual loss of $1,320. Additionally, we estimate wolves could kill 85 calves annually at an annual loss of approximately $25,000, and kill 200 sheep annually at an additional loss of approximately $20,000. These are statewide estimates, and local impacts might vary considerably.

One approach to reducing the financial impacts of predator depredations on livestock has been the establishment of compensation programs that pay ranchers for depredated livestock. Currently, Defenders of Wildlife pays compensation for confirmed and probable losses of sheep, cattle, and pets that result from wolf depredation. Payments made to ranchers in 2000 for both probable and confirmed livestock losses in Wyoming, Idaho, Montana, Arizona, and New Mexico totaled $50,446.25.

The cornerstone of any Utah wolf management plan will clearly be developing strategies for minimizing wolf-livestock conflicts, and instituting mechanisms for dealing with those that do occur. We advocate the protection of rural interests, promotion of public tolerance, and responsible management and protection for wolves as key elements in a wolf management program. Responsible wolf management ensures that the resolution of wolf-livestock conflicts meets the interests of livestock producers, natural resource managers, and the general public.

We propose a wolf education program that should provide science-based, factual information about wolf ecology and management. Wolf management issues are likely to be highly publicized and volatile, so it is important that the information being disseminated is accurate and consistent with the goals of the agencies involved. Educational programs should be multifaceted and address all of the relevant issues. We recommend a program that educates the public about wolf-related issues and concerns in Utah in order to compliment viewpoints based on common myths (both pro and con), as well as on personal opinions, experiences, and biases.

There is precedent for tribal cooperation in wolf recovery. For example, when the state of Idaho refused to participate in wolf reintroduction, the Nez Percé Tribe took responsibility. The tribe manages wolves throughout the Central Idaho Recovery Area, although the Nez Percé reservation includes only about 304 square km. Although we do not foresee a similar situation developing in Utah, the cooperation of Native Americans living and working in and around potential wolf habitat would seem essential. In particular, the Uintah and Ouray Reservation, managed by the Ute Tribe, includes a substantial portion of the largest contiguous area of high-quality wolf habitat in Utah. The Ute Tribe, at present, does not support wolf reintroduction, although their position on natural recolonization is unclear.

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Finally, we would like to thank Hilary Davis for creating the cover art.

Wolves in Utah

1. Introduction

The historic range of gray wolves (*Canis lupus*) in Utah was essentially statewide (Barnes, 1922; Durrant, 1952). Although their presence cannot be disputed, the historic abundance of wolves in Utah is unknown. The presence of Lake Bonneville throughout the late Pleistocene, and its subsequent draining 14,000 years ago (Short and Blair, 1986), must have had profound impacts on the distribution and abundance of the regional biota. Historic gray wolf abundance would have been a function of ungulate densities, with large ungulate populations associated with increased wolf densities. However, according to Durrant (1952), writings of early European explorers in the region later known as Utah recorded that mule deer were relatively scarce. Consequently, wolves probably were not found in high densities throughout the region, but rather occurred in pockets of high ungulate density. These wolves would have competed with grizzly bears, black bears, mountain lions, and coyotes for available ungulate prey or carcasses. Aggressive predator management policies essentially eliminated gray wolves from Utah by the early part of the 1900s, and by 1929 wolves were considered extirpated in the state (La Vine, 1995).

The release of gray wolves into Yellowstone National Park and central Idaho in 1995 established growing populations, and increasing dispersal is bringing these wolves closer to Utah (for an overview of the status of wolf recovery in the northern Rockies, which deals with many of the issues we have addressed here, see Bangs et al., 1998; or Bangs et al., 2001). In addition, wolf proponents are currently advocating the establishment of a southern Rockies gray wolf population centered in Colorado, which also could disperse into Utah, as well as a role for Mexican wolves in northern Arizona. Therefore, it seems likely that wolves will commingle with Utah's other native mammals in the near future.

The potential presence of wolves in Utah is generating a series of questions and debates. These include the following:

- What is the current status of wolves in the West? How likely is it that wolves will end up in Utah? If they do, what is their legal status?
- Where is the best wolf habitat? What are the key variables in determining potential wolf habitat? How many wolves could live in Utah?
- How do people in Utah feel about wolves?
- What is the potential for wolf-human conflicts in Utah?
- How can livestock depredation on private lands and public lands be prevented or minimized? Will the presence of wolves lead to restrictions on public land use?
- How will we deal with livestock depredations when they occur? What can ranchers do to protect their livestock if wolves are present?
- How would ranchers be compensated for wolf predation of their livestock? Who will pay for depredations?
- Will wolf predation depress game populations? Will wolves reduce hunter opportunity or success?
- Who will manage wolves? Who will pay for management? Should Utah develop a management plan? What process should be used to develop a wolf management plan for the state of Utah?

This report has been developed to answer many of these questions, stimulate discussion on others, and make recommendations that should assist in the integration of wolves into the social, economic, and biological fabric of Utah. It is organized by topic, each of which is readable as an independent section. Where appropriate, reference is made to related sections.

In developing this report, we reviewed hundreds of documents, many of which are referenced at the end of this report. We believe we have captured the general flavor of the relevant published and unpublished literature regarding gray wolves. In addition, to utilize the most current information, we have incorporated references from experts making public presentations over the past two years, again noting the occasion and venue of the presentation in the literature cited section at the end of this report.

Throughout this analysis, we have strived to maintain an objective perspective. You will note that as a starting point we assume that wolves will inhabit Utah in the near future. We cannot set a date for this occurrence, nor do we outline the mechanism for wolf recolonization. The means could include natural or facilitated recolonization, or active reintroduction. While we do not advocate any particular mechanism, we refer exclusively to recolonization throughout this document. Starting from the assumption that wolves will return to Utah, we have attempted to answer many of the questions raised above, and have not avoided the tough ones. Therefore, on numerous occasions, we make predictions regarding the social and economic impacts of wolf recolonization on the livestock industry, on hunter success, and on wildlife managers, and then make recommendations on possible ways to mitigate these impacts. We attempt to put the issues on the table, and we encourage full and thorough debate on all aspects of wolf management. The needs and wishes of all Utahns, the preservation of Utah's wild environments, and the legacy we leave to future generations require nothing less.

2. Legal Issues Pertaining to Wolves in Utah

2.1. Current Status

The United States Fish and Wildlife Service (USFWS) classifies gray wolf populations as either *endangered, threatened,* or *nonessential/experimental*. Each of these designations carries different levels of protection and is associated with different management options. Currently, wolves are classified as fully endangered throughout most of the United States, and thus enjoy the most stringent level of protection under the Endangered Species Act (ESA). In Minnesota, where wolves are classified as threatened, these protections are relaxed somewhat to allow federal specialists to kill depredating wolves, although strict guidelines must be followed (MN DNR, 2001). On the other hand, reintroduced wolf populations in Idaho, Wyoming, Montana, New Mexico, and Arizona have been designated as nonessential/experimental. Under this designation, depredating wolves can be killed or relocated by federal, state, or tribal agencies and, under some conditions, harassed or killed by members of the public (USFWS, 1994). Finally, species classified as threatened or endangered are usually assigned a critical habitat designation, within which land-use activities may be regulated to avoid harm to the species. However, this does not occur under experimental/nonessential status [16 U.S.C.A. 1536 § 10(j)(2)(C)(ii)].

2.2 Future Scenarios

Currently, the USFWS is leading the effort to restore gray wolves to the northern Rockies. The Northern Rockies Recovery Area consists of three separate populations. In two of the three areas, Yellowstone National Park (Yellowstone) and central Idaho, wolves were actively reintroduced by the USFWS, whereas wolves naturally recolonized the third area, near Glacier National Park in northwestern Montana. Wolves in the first two populations are classified as nonessential/experimental, whereas in northwestern Montana they are classified as endangered. The ultimate goal of this recovery effort is to remove wolves from the endangered species list ("de-list"), after certain population objectives have been met. A recent USFWS decision modified the original objective of maintaining 10 breeding pairs of wolves in each of the three recovery areas for three consecutive years (USFWS 1994). The new criterion requires a total of 30 breeding pairs for three consecutive years in the recovery area as a whole (E. Bangs, USFWS, personal communication). Because the 30 breeding-pair criterion was met in 2000, and again in 2001, the USFWS is now in the third year of the countdown (Meier, 2001; D. Smith, 2001; Babcock et al., 2001; E. Bangs, USFWS, personal communication). This is the first step toward removal from ESA protection. However, a number of wolf advocacy groups have questioned the biological basis for this alteration in the recovery goals (Tollefson, 2001) In any case, de-listing will be incumbent upon the creation of satisfactory state wolf management plans in Wyoming, Idaho, and Montana. While Montana and Idaho are currently developing management plans (Idaho Legislative Wolf Oversight Committee, 2000; Montana Wolf Management Advisory Council, 2002), Wyoming is in a very preliminary stage of developing their plan, which will almost certainly delay the de-listing beyond the 2003 target set by the USFWS.

Once a wildlife species is removed from the endangered or threatened list, it becomes the responsibility of the states in which it occurs. Therefore, if wolves are de-listed, the state of Utah will assume the responsibility for managing any wolves in the state. Although under this scenario Utah would not be legally required to create a wolf management plan, we feel strongly that such a plan should be in place. A state plan would facilitate responsible decision making, integrate wolf management with the needs and wishes of Utah citizens, and help minimize conflicts by addressing local conditions. Furthermore, the existence of a Utah state plan would facilitate the de-listing process (E. Bangs, USFWS, personal communication.). In the meantime, any wolves that are found in Utah will remain under USFWS jurisdiction and be managed as a protected, endangered species.

In the short term, it is likely that the USFWS will "downlist" wolves from endangered to threatened status. The initial criteria for downlisting have already been met, and this process does not require adoption of acceptable state management plans. As part of the current USFWS downlisting proposal, four so-called "Distinct Population Segments" (DPS) would be created. The Western DPS would include Washington, Oregon, Idaho, Montana, Wyoming, Colorado, northern New Mexico, northern Arizona, and Utah. If this plan is adopted, wolves would be reclassified as threatened throughout the Western DPS, with the exception of those populations already designated nonessential/experimental. Although the USFWS would retain primary responsibility for wolf management under this scenario, state agencies in Utah would probably play a significant role. Once again, a Utah wolf management plan would be useful, especially considering that downlisting could be followed relatively quickly by de-listing.

There is an alternative scenario, in which de-listing of the wolf in the northern Rockies would not necessarily lead to de-listing in Utah. A number of nongovernmental organizations are currently petitioning the USFWS to create a Distinct Population Segment in the southern Rockies, an area that would include Colorado, Utah, and northern New Mexico (Phillips et al., 2000). Under this scenario, wolves could remain endangered in Utah, even if they were de-listed in the northern Rockies. Designating a separate DPS would require a finding by the USFWS that a southern Rockies wolf population would be significant to the species as a whole. As the USFWS indicates (USFWS et al., 2000), there are no hard and fast rules for determining this significance. According to their 1996 Vertebrate Population Policy (61 FR 4722), the USFWS considers whether a population is defined by physical, physiological, ecological, and behavioral barriers or by a governmental boundary that coincides with differences in management policy, but does not require that a DPS be completely isolated. This scenario (creation of a Southern Rockies DPS) could lead to active reintroduction of wolves in the region. Any reintroduced populations could be designated "nonessential/experimental," as has been done in Yellowstone and central Idaho. In any case, the current position of the USFWS is that there are no distinctions within the Intermountain West that justify a DPS for any subregion. Further down the road, de-listing of this hypothetical Southern Rockies DPS would be incumbent upon the adoption of satisfactory state plans by Colorado, Utah, and New Mexico The states would assume control over wolf management; however, wolves would be monitored by the USFWS for five years after

de-listing, and could be re-listed if recovery fails (16 U.S.C.A. 1536 § 4(g)(1)). Clearly, under this scenario, creation of a state management plan would be necessary. In summary, then, no matter what the eventual outcome of this process is, Utah will need to have a wolf management plan in place at some point.

3. Current Public Attitudes toward Wolves in Utah

A critical aspect of wildlife management is the influence of public opinion on the design and implementation of wildlife policy. Although surveys conducted across the nation tend to reveal strong support for endangered species protection and restoration in general (Duda et al., 1998), as well as support for gray wolf recovery, there is significant variation among different regions and interest groups, including those within Utah (La Vine, 1995).

La Vine (1995) conducted a survey of 707 Utah residents and public land-grazing permittees regarding their attitudes toward wolves. The survey was statistically weighted in order to overrepresent rural residents. According to this survey, the Utah public in general held fairly positive attitudes toward gray wolves (Figure 1). Southern rural residents had the most negative perceptions of wolves, whereas metropolitan residents had the most positive perceptions. Northern rural residents had intermediate attitudes. A study of Colorado residents found responses similar to La Vine's (Pate et al., 1996). Respondents in the Colorado study were divided in opinion depending on place of residence. Those residing east of the Continental Divide were more supportive of reintroduction and felt more positive toward wolves in general. Those residing on the sparsely populated west side of the Continental Divide were less in favor of reintroduction and possessed more negative attitudes toward wolves in general. Such findings suggest that rural and urban residents have differing attitudes toward wolves, regardless of state of residence.

Although a majority of Utah residents held either positive or neutral attitudes toward wolves, those that held permits to graze cattle and sheep on public lands in the state (permittees) expressed negative attitudes toward wolves (64% disliked or strongly disliked). In contrast, big-game hunters were rather evenly divided. Permittees and hunters were more informed about wolves than the general public, although the majority of respondents scored highly on a variety of wolf-related knowledge questions. These differences highlight the difficulties that policy makers and managers are likely to encounter.

Wolves in Utah

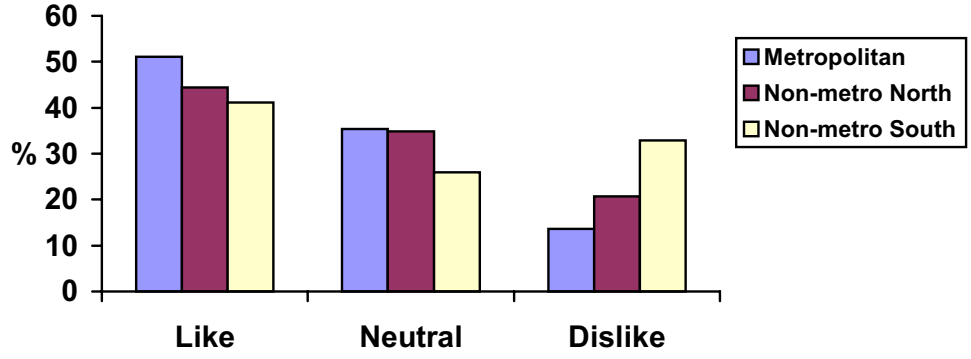

Figure 1. Utah residents' attitudes toward wolves (La Vine 1995).

A comparison between Utah and other states currently involved in wolf restoration can be used to give managers some idea of how the presence of wolves affects attitudes. La Vine compared Utahns' attitudes with the attitudes in other states including Montana, Wyoming and Idaho (Figure 2), using a number of other studies. Utahns held somewhat more polarized views (both positive and negative) toward wolves than residents of Montana, Wyoming, and Idaho (La Vine, 1995). In general, however, the attitudes of Utah residents mirrored those of other states, in that they were generally positive.

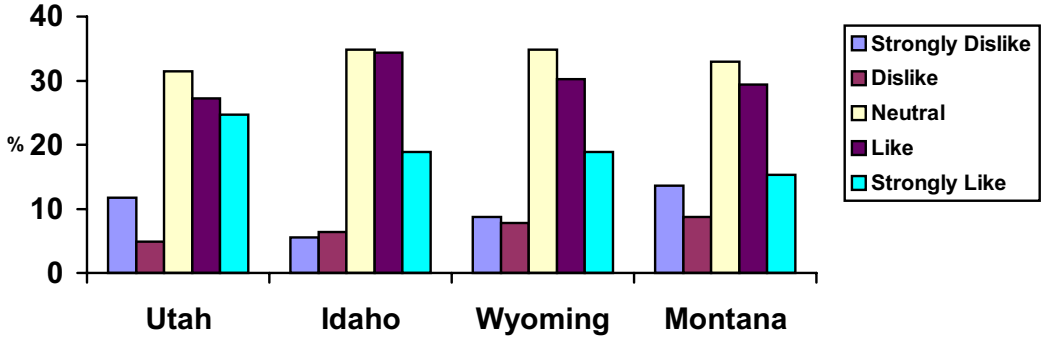

Figure 2. Comparison of attitudes toward wolves by state (La Vine, 1995).

La Vine also specifically compared the attitudes of Utah residents with residents of Montana's North Fork of the Flathead River, where wolves currently live. When asked if a person in wolf country is in danger of being attacked, only 57% of Utahns disagreed, while an overwhelming majority of 80% of North Fork residents disagreed with the statement. This suggests that Utah residents were more fearful of wolves and that Montanans' greater exposure to wolves has made them less fearful.

The most recent wolf-related attitude survey (Decision Research, 2001), conducted in Colorado, New Mexico, and Arizona, found very strong support in all three states for

wolf reintroduction in wilderness areas (68% favored reintroduction in Arizona and Colorado, 59% in New Mexico). Fewer than 15% in each state agreed that wolves should be kept out of all public and private lands.

Because wolf restoration is both a biological and sociopolitical issue, attention should be given to the current attitudes of Utah residents. While Utahns as a whole were generally in favor of wolves, with the exception of permittees, approval of wolves differed between nonmetropolitan and metropolitan areas. This pattern is consistent with findings in other areas, where those most likely to be directly affected by potential wolf recovery (i.e, rural residents) tend to display the most negative attitudes. Utah has a unique social climate in comparison to the surrounding states, but consideration of other attitude studies hints that as wolves gain a foothold in the state, attitudes may shift. Wolves have been reintroduced in relatively close proximity to Utah since La Vine's survey was initiated in 1995. This may have had a significant effect on the attitudes of Utah residents. In addition, the rapidly changing demographics in the state (e.g., increased urbanization) over the past seven years might be expected to lead to significant changes. For these reasons, we recommend that a reassessment of attitudes toward wolves in Utah be an integral part of any wolf planning and management process.

4. Biological Aspects of Wolf Recolonization in Utah

Wolves have been one of the most scientifically examined of all wildlife species (Mech, 1995b). Many studies have focused on the effects of wolf reintroductions and recolonization. In this section, we address how wolves may naturally disperse into Utah, highlight areas identified in our habitat model as constituting the most favorable wolf habitat in Utah, estimate potential wolf populations in Utah**,** and describe what is currently known about the influence of wolves on an ecosystem.

4.1. Natural Recolonization

The wide-ranging dispersal ability of wolves has been well documented (e.g., Gese and Mech 1991). Dispersing wolves can travel hundreds of kilometers in search of potential mates (Mech [1970] 1981). In fact, one female wolf from Glacier National Park, Montana, was killed more than 800 kilometers north of its natal pack's territory (Ream et al., 1991). When released from anthropogenic hunting pressure, wolves can quickly recolonize former habitat (Hayes and Harestad, 2000). For example, when the eastern timber wolf in Minnesota was listed as a federal endangered species in 1974, the taking of wolves was prohibited, and wolves quickly expanded their range both within the state of Minnesota and as well as the neighboring states of Wisconsin and Michigan, where they had been extirpated (Fuller et al., 1992). Additionally, during the 1980s, wolves dispersing from Canada recolonized northwestern Montana. Wolves reintroduced to Yellowstone National Park (Yellowstone) are dispersing and establishing packs outside of the park (Smith et al., 2000). Several lone Yellowstone wolves have traveled relatively far outside of the Greater Yellowstone Ecosystem (GYE) (Figure 3). Furthermore, an unconfirmed sighting of a possible lone wolf in the Mount Naomi Wilderness in the Bear River Range of northern Utah occurred in 2000 (Associated Press 2000), and a wolf was suspected of killing sheep about 40 kilometers southeast of Logan in July, 2002 (Israelsen, 2002).

If wolves in the northern Rockies are allowed to expand their population, dispersal outside of the GYE will be inevitable. Some wolves will travel south toward Utah. Geographic Information Systems (GIS) analysis has shown high connectivity of intact habitat between the GYE and both the Bear River Range of northern Utah and Flaming Gorge National Recreation Area (Jones and Tingey, 2001). At present, these corridors are the most likely avenues of dispersal to Utah. However, additional reintroductions are being advocated in both the Grand Canyon Ecoregion (P. Sneed, personal communication; see also Sneed, 2000) and in the southern Rockies of Colorado and New Mexico (Phillips et al., 2000). Canyon National Parks and the Dixie National Forest, as well as from the east via the Book Cliffs or La Sal Mountains, all of which constitute favorable habitat according to our habitat model (see Section 4.2).

Despite these avenues for possible dispersal, a number of human factors may prevent wolves from establishing a viable population in Utah. Dispersing wolves typically suffer

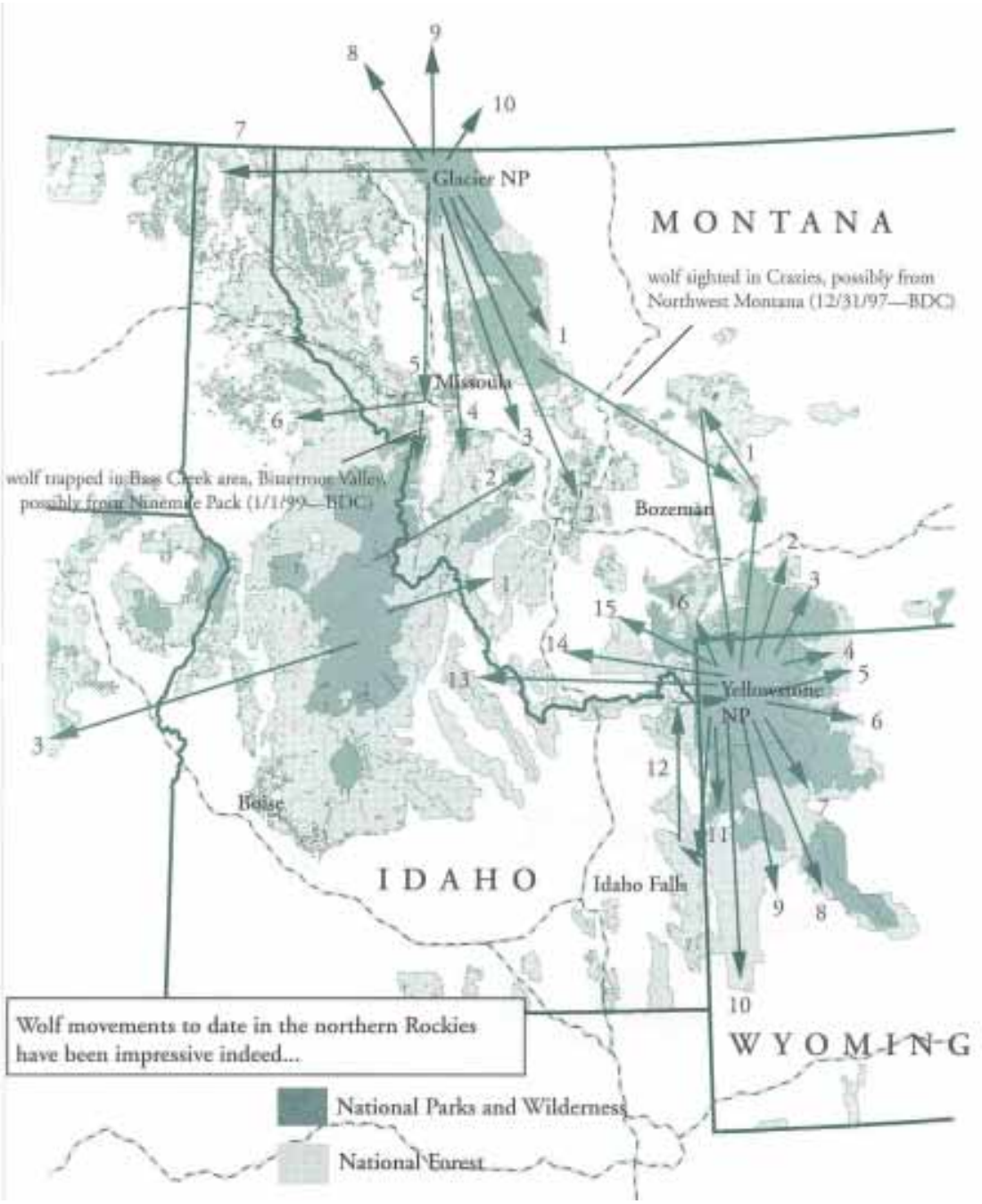

Figure 3. Wolf movements in the northern Rockies, 1986 to early 1999 (Gaillard et al., 1999; reprinted with permission). Each arrow depicts an individual wolf's approximate dispersal route.

higher rates of mortality than resident wolves (Peterson et al., 1984). Many wolves that disperse south from the Idaho recovery area are presently being relocated or euthanized by the U.S. Fish and Wildlife Service, largely because of conflicts with livestock. However, wolves dispersing into Oregon will, in general, no longer be relocated unless conflicts occur (E. Bangs, USFWS, personal communication). Other barriers to wolves dispersing from the GYE include poaching, automobile collisions, and relatively narrow habitat corridors. Since reintroduction in Yellowstone, more than 30 human-caused mortalities of wolves have occurred outside of the Park (Phillips and Smith, 1997; D. Smith 1998; D. Smith et al., 1999b, 2000). Additionally, the reintroductions being advocated for the Grand Canyon Ecoregion and southern Rockies of Colorado and New Mexico may never occur.

As a consequence of these factors, it might take many years for even a single resident pack to become established in Utah. A single pack would be unlikely to survive long enough to found a truly viable population. Accordingly, a self-sustaining population of wolves might not be possible in Utah without human intervention. If Utah residents and policy makers decide that a viable population of wolves within Utah in the next few decades is desirable, reintroduction may be necessary. In either case, however, it will be important to identify likely wolf habitat across the state to facilitate the implementation of proactive measures designed to reduce conflicts with humans and livestock.

Which subspecies of wolf historically inhabited Utah is a matter of debate. North American wolves were once categorized as 24 separate subspecies (Hall and Kelson, 1959). Nowak (1995), however, identified only five subspecies in North America, with *Canis lupus nubilus* occupying most of the western United States. Using genetic evidence, Forbes and Boyd (1996) suggest that distinct subspecies of wolves may not exist, but rather that genetic variation is continuous with distance. *Canis lupus occidentalis* from British Columbia and Alberta were reintroduced into Yellowstone because of similar habitat and prey base between the three areas. Any wolves dispersing to Utah from the north would be this same subspecies. For this reason, if wolf reintroduction were to be implemented in northern or central Utah, we would recommend using either *C. l. occidentalis* or *C. l. nubilis.* However, the wolves that originally inhabited southern Utah may have been more closely related to the Mexican wolf, *C. l. baileyi.* In addition, any further reintroductions in Arizona will almost certainly utilize Mexican wolves. For this reason, a recovering wolf population in Utah might consist of *C. l. occidentalis* or *C. l. nubilis* in northern Utah with genetic gradation to *C. l. baileyi* in southern Utah.

4.2. Assessment of Potential Wolf Habitat in Utah

We have identified areas in Utah where dispersing wolves are most likely to colonize, as well as those that are most suitable for the establishment of self-sustaining wolf populations. In addition, we have derived estimates of the number of wolves that each area could support over the long term. Although we have used the best data available for this analysis, the results are preliminary, and should be viewed as such. For example, we have not explicitly included geographic proximity to possible migration corridors into Utah as a consideration, although such proximity could be an important determinant, at

least in the initial stages of a recolonization event. Our focus was directed more toward identifying all areas of potential wolf habitat. We also recognize that some areas with the potential to support wolves may not be considered appropriate for other reasons, such as the presence of high densities of livestock.

Habitat selection by wolves is complex and not yet completely understood. Fundamentally, wolves tend to locate in areas that have both an adequate prey base and a minimum of human interference (Mech, 1995a; Mladenoff et al., 1995). We have used coarse-scale population estimates of ungulates in combination with likely distributions among habitat types, both obtained from the Utah Division of Wildlife Resources (DWR), to identify areas in Utah that support adequate prey populations, and are therefore capable of supporting wolves. It should be noted, however, that these population estimates are very approximate because extensive field data are not available. Wolves are ecologically adaptable and have shown a capacity to persist in close proximity to human populations, given an adequate prey base (Boitani, 1982; Mech, 1995a; Blanco, 2000). However, because of the very high percentage of adult wolf mortality that is human associated, primarily the result of intentional and unintentional shootings and highway deaths, viable populations should be more likely to persist in relatively isolated areas (Thiel, 1985; Fuller, 1989; Thurber et al., 1994; Pletscher et al., 1997). Road density is a commonly used surrogate for probable levels of human-associated wolf mortality (e.g., Mladenoff et al., 1995) and has been shown to be a robust predictor of wolf colonization in the Great Lakes region (Mladenoff and Sickley, 1998). For this reason, we have used low road density as the other primary criterion in determining the favorability of potential wolf habitat.

In addition to low road density and adequate prey, several other factors are important in delineating suitable wolf habitat. Wolves require year-round access to fresh water, especially during denning (Mech [1970] 1981); however, few data are available regarding how access to water may affect pack territory size or location. Accordingly, we used proximity to perennial streams and lakes as a criterion. In addition, wolves tend to avoid high elevations and rugged terrain (Carroll et al., 2001), presumably because of the difficulty of catching prey on a year-round basis, as large ungulates tend to migrate to lower elevations in winter. Although many other factors can affect wolf habitat selection, we have selected these five (adequate prey, low road density, year-round access to water, appropriate elevation, and appropriate topography) as critical to a preliminary designation of favorable habitat. It is important to keep in mind that although these criteria are generally accepted as applicable, it is not entirely clear whether the unique topography and climate of Utah may interact to alter wolf habitat selection in unpredictable ways.

We have used a Geographic Information Systems (GIS)-based approach to construct a "static" habitat suitability model for Utah. The model is static in the sense that population dynamics were not considered in evaluating habitat. Areas with the biological potential to support wolves were identified using this model. Essentially, we generated GIS coverages for each habitat attribute, and generated a habitat "score" ranging from least favorable to most favorable for each point on the coverage, depending on the value of the habitat attribute at that point. The exception was the initial step, in which road density

was used in a linear regression equation to predict probability of wolf occupancy, using the method developed by Mladenoff et al. (1995). Areas with a predicted probability of occupancy of less than 50% were not considered further. For this reason, our estimate of the total area of favorable wolf habitat should be considered conservative, and is probably an underestimate. The habitat scores were assigned using information obtained from both the scientific literature and from consultations with wolf biologists. A detailed enumeration of how the scores were developed is available upon request. Once areas of favorable habitat had been identified using this model, we used two methods to estimate the number of wolves that the best-quality habitat would likely support, and applied simple but robust population modeling techniques to estimate the long-term viability of wolf populations in each area.

A map of the resulting habitat model is shown in Figure 4. It can be seen that most of forested, mountainous Utah, an area of over 36,000 km^2, has the potential for wolf recolonization. However, because of high road densities, our model scored many parts of these areas as marginal wolf habitat, resulting in a substantial degree of fragmentation. Despite this fragmentation, a number of relatively large, contiguous areas of high-quality habitat can be identified from this map. The largest of these areas, approximately 5,900 km^2, is in the Book Cliffs region, extending eastward over much of the Tavaputs Plateau. A relatively large proportion of this potential habitat is on the Uintah and Ouray Indian Reservation, with the rest being primarily under the jurisdiction of the Bureau of Land Management (BLM). Other areas with a high potential for supporting wolves include (1) eastern Daggett County along the Green River (~350 km^2), most of which is again administered by the BLM; (2) the area northwest of Starvation Reservoir in the lower elevations of the Uinta Mountains (~330 km^2), which falls partly in Ashley National Forest and partly on the Uintah and Ouray Indian Reservation; (3) an area near Boulder (~1,880 km^2) that includes Boulder Mountain (Dixie National Forest) and parts of Grand Staircase/Escalante National Monument and Capitol Reef National Park; (4) an area southwest of Ferron (~1,160 km^2) that is split between the Manti-La Sal and Fishlake National Forests; and (5) the Kolob Terrace (~350 km^2), south of Cedar city, partly in the Dixie National Forest and partly in Zion National Park.

Although we focus on these areas, it should be noted that a number of other areas have the potential to support wolves. One of the weaknesses of this type of approach is that we were unable to include a measure of actual road use in our road-density calculation. Clearly, not all roads will have similar effects on wolf mortality, and hence habitat that appears to be highly fragmented in our model may in fact be relatively contiguous. For that reason, we suspect that the habitat we have identified may be an underestimate. On the other hand, land ownership and land use are certain to have a dramatic impact on whether habitat identified using this model is in fact capable of supporting wolves. We have chosen to focus on a relatively small number of areas that are largely under public ownership. However, some corridors between the core areas overlap private land where potential conflict would be higher. In addition, livestock grazing occurs in or near many of these areas, which also raises the potential for conflicts. These issues will need to be

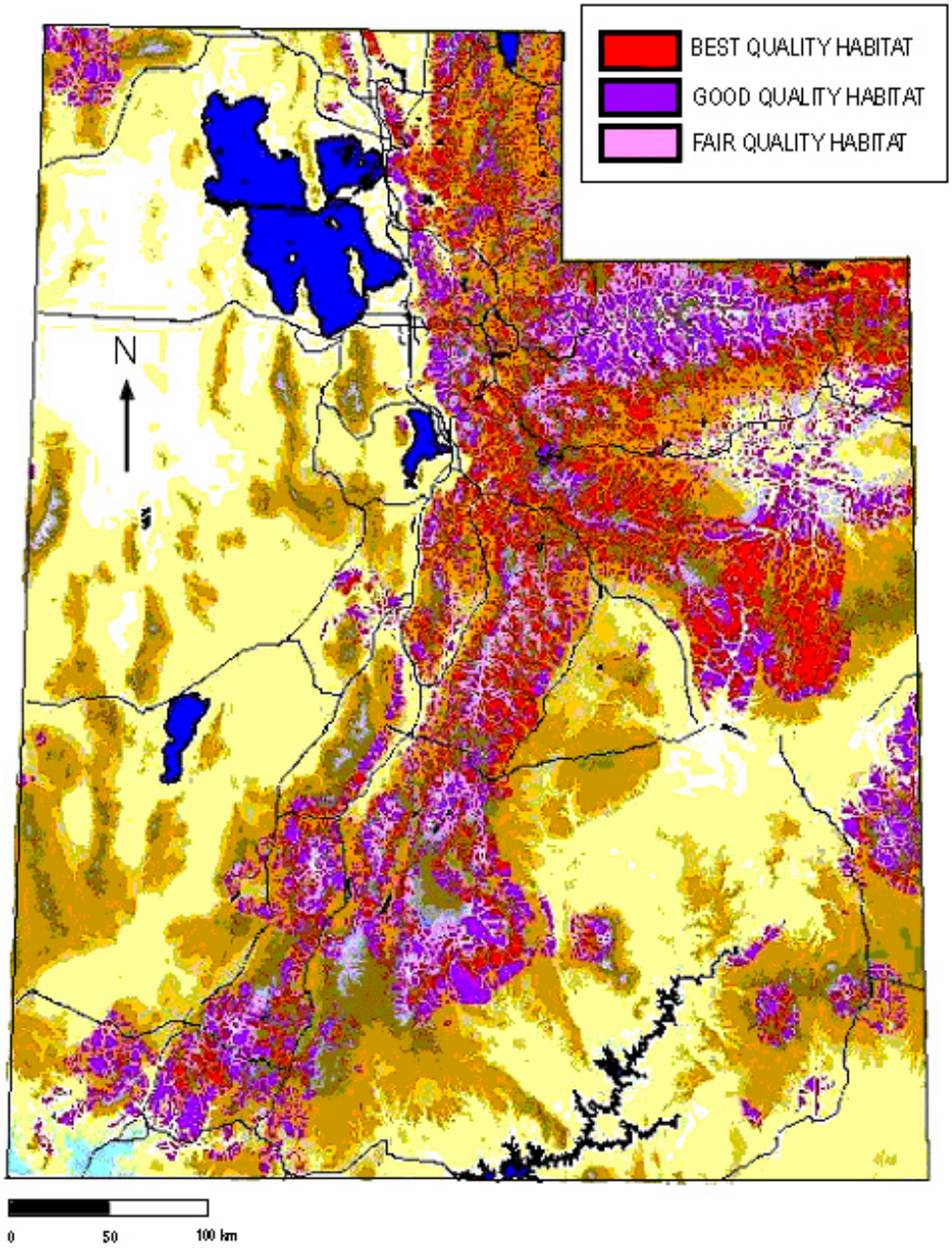

Figure 4. Potential wolf habitat in Utah overlaid on a Digital Elevation Model (DEM). Areas that scored as suitable habitat are shown in pink, purple, and red. The DEM is shaded from light blue (lowest elevation) to lavender (highest elevation). Major roads are shown in black.

considered carefully. Our goal was simply to identify those areas of Utah that were likely to be the most favorable for wolves in a biological sense.

4.3. Estimates of Potential Wolf Populations in Utah

To estimate the number of wolves that Utah might support, we used two methods. The first, developed by Fuller (1989), relates ungulate density, normalized to "deer-equivalents," to a predicted overall wolf density in an area. Using this method, in combination with the Utah DWR's coarse-scale estimates of ungulate populations, we calculated likely wolf densities. We then used these estimated densities to calculate the total wolf population that could be supported, both in each area of contiguous high-quality habitat, as well as statewide. The results of this analysis are given in Table 1. The statewide estimates were derived by assuming that approximately 2/3 of the 36,000 km^2 of favorable wolf habitat would be occupied. This seems very unlikely, even under the most favorable political and social conditions, and therefore a calculation based on this assumption should provide an upper limit for total wolf numbers in the state. Using this assumption, we calculated that Utah could, in theory, support approximately 700 wolves (see Table 1) distributed throughout the state. We applied the same method to the six areas of favorable habitat identified above, which we refer to as "core" habitat areas. The number of wolves each area might support varies from 6 (Green River and Kolob Terrace) to more than 100 (Book Cliffs). Taken together, we estimate that the core habitat could, in theory, support just over 200 wolves.

An alternative method uses ungulate densities to estimate average pack-territory size (Fuller, 1989). Wolf populations can then be calculated on the basis of this estimate, in combination with estimates of average late-winter pack size, percent of wolves not belonging to any pack, and proportion of habitat in interstitial territory, using a relationship developed by Fuller et al. (1992). These parameters are difficult to estimate accurately, however. Average pack size, in particular, has a large influence on the population estimate, and average pack sizes have been reported to vary from 5 to 12 animals (see e.g. Fuller, 1995). Accordingly, this calculation may be more uncertain. Nevertheless, estimates using this method were generally similar to those found using the previous method. For simplicity, we refer only to population estimates derived using Fuller's (1989) method.

In the previous analysis, we calculated the theoretical wolf population that could be sustained by a given prey density. However, under any recolonization scenario, including active reintroduction, the initial population size will be small. In an attempt to determine the likely fate of an initially small wolf population in Utah, we used population-modeling techniques. We used the VORTEX population-viability analysis software package (Lacy, 1994), as well as a simple stochastic population model designed by one of the authors (T. Simmons, 2001, unpublished data) to examine the fate of a small colonizing wolf population in the large high-quality habitat patch identified in the Book Cliffs (the details of these analyses are available upon request). VORTEX follows the fate of each individual in the population, but is not designed to model species with complex social

Table 1. Estimates of Potential Wolf Populations in Utah

Core Habitat Area	Estimated Number of Wolves Supported
Book Cliffs	102
Green River	6
Southern Uinta Mountains	7
Boulder Mountain	43
Fishlake/Manti-La Sal	50
Kolob Terrace	6
Total for Core Habitat Areas	**214**
Statewide (Core + Peripheral) Total	**711**

behaviors such as gray wolves. Our model attempted to take the unique reproductive behavior of wolves into account, but dealt with the population as a whole. Both approaches led to essentially the same conclusion: In the absence of immigration (i.e., a constant supply of dispersing wolves from outside the area) or a concerted effort to minimize human caused mortality, a small (10-15 animals) colonizing population would increase only very slowly at best, and would be subject to a high risk of local extinction. Higher starting populations (15-30 animals) gave similar results, although the risk of local extinction decreased. The modeling results suggest that the wolf population in Utah is unlikely to reach significant numbers in the absence of human intervention, although these types of theoretical approaches are highly uncertain (Fritts and Carbyn, 1995).

Because we were interested in assessing the likely impacts of wolves on, for example, livestock in Utah, we needed to select a wolf population level or range of levels to conduct that assessment. Given the inherent uncertainty in forecasting population growth, we felt it would be prudent to select a number that was higher than we believed was likely to occur, at least absent a concerted recovery effort by the state. Because the highest-quality, relatively contiguous habitat patches are predicted to support a maximum of 214 wolves (Table 1), 200 would seem to be a reasonable number for assessing the maximum potential economic and social impacts of wolves in Utah. For these reasons, we have assumed a wolf population of 200 for all further analyses.

4.4. The Effects of Wolf Recolonization on Ecosystems

Wolf restoration efforts throughout the United States are increasing significantly our knowledge of the ecological functions of wolves and their effects on ecosystems. Wolves are a top-level predator whose presence is an indicator of an ecosystem's integrity. Although the literature suggests that recolonizing wolves will probably have a small effect on the dynamics of Utah's ungulate populations, they may exhibit a greater influence through changes in ungulate behavior and cascading effects. It has been more than seven years since wolves were reintroduced into Yellowstone National Park. Although long-term data are not yet available, wolves seem to be demonstrating significant effects throughout that ecosystem. The results of this natural experiment can help us gauge the potential effects of wolves on Utah's ecosystems and will be cited

frequently in this section. In this section we review current literature regarding how wolves may affect ungulate populations, ungulate behavior, and other predators and scavengers. In addition, we estimate the magnitude of the impact of wolf predation on ungulate populations in Utah.

Ungulate Populations

Much concern has been expressed over the impact of wolves on deer and elk populations in Utah (UT DWR 2001a; Peay, 2001a, 2001b). The degree to which wolves may regulate or limit prey populations remains controversial (Gese and Knowlton, 2001). This debate stems from the difficulty of large-scale, long-term studies, lack of adequate replication or controls, and differing interpretations of the same data. Despite these constraints, a number of studies have described the influence of wolf predation on wild, native ungulate populations (reviewed by Bennett, 1994 and Ballard et al., 2001). Because limited research has addressed the interaction between wolves and mule deer, or been conducted in habitat similar to that found in Utah, we have relied on studies from other areas (the Great Lakes, Canada, and Alaska) that deal primarily with other prey species (white-tailed deer, elk, Dall sheep, caribou, bison, and moose).

Typically, wolves do not appear to dramatically reduce prey populations (e.g., Van Ballenberghe, 1985; Fuller, 1990). Rather, wolf predation appears to generally dampen fluctuations in prey numbers (e.g., Leopold, [1933] 1986; Pimlott, 1967; Carbyn, 1983). One reason for this may be that wolves generally seize upon the most vulnerable prey (e.g., young, old, sick, and injured), which are the easiest animals to catch and kill (e.g., Murie, 1944; Fuller and Keith, 1980; Kunkel and Pletscher, 1999). This is quite different from human hunting, in which different selection criteria operate. For example, since 1995, the average age of wolf kills in Yellowstone and the National Elk Refuge in Wyoming has been 14 and 19 years, respectively, whereas hunter kills averaged 6 years of age in both areas (D. Smith, 2001; B. Smith and Berger, 2001). Furthermore, a study in Idaho demonstrated that hunter-harvested elk are generally in much better physical condition than those killed by wolves (Power, 2001). Accordingly, wolves may actually improve the health of an ungulate herd by removing either diseased or disease-prone animals that could act as vectors to an entire herd (Mech, 1966; Carbyn et al., 1993). Finally, predators, by preying on smaller, weaker individuals, may select for larger, healthier ungulates over the long term (e.g., Kie et al., 1979; Knowlton and Stoddart, 1992).

In general, predation can be defined as either compensatory mortality, in which an additional form of mortality reduces other causes, or as additive mortality, in which predation increases the overall mortality rate (Bartmann et al., 1992). For example, wolves killing a winter-weakened ungulate would be defined as compensatory predation if the death of that animal from other causes was inevitable, as is often the case. On the other hand, predation by wolves and other large predators has, at least in some cases, been shown to be additive. These studies, most of which were conducted in Alaska and Canada, suggest that predation by wolves in combination with other predators, including humans, can limit prey populations (reviewed in Kay, 1996; Kunkel and Pletscher, 1999).

However, such limitation may occur primarily when prey populations have been severely reduced by other factors. These factors could include hunting, poor habitat, extreme weather, food availability, changes in the age or sex structure of the population, disease, competition with livestock and other wildlife species, as well as interactions between these factors (Ballard et al., 2001; Mech and Nelson, 2000). For example, Van Ballenberghe and Ballard (1994) found that wolf predation was a limiting factor in the recovery of a reduced moose population in Alaska, when there was minimal human influence, little alternative prey, and additional predation by brown bears.

Severe weather appears to be the primary limiting factor for ungulate populations in Yellowstone, Minnesota, and Wisconsin. Although elk are the primary prey for Yellowstone wolves (>90%), the Yellowstone Northern Range elk herd, following a substantial winter die off in 1996/1997 and subsequent high hunter-harvests in the spring of 1997, has recovered (D. Smith, 2001). Overall, the elk herds have remained very stable throughout wolf recovery (D. Smith, 2000), possibly because wolves are preying on very old elk that might otherwise die off in the winter (Houston, 1978; Singer and Mack, 1999). In Minnesota, despite high wolf numbers, white-tailed deer have recovered quickly from a reduction of 45%-50% due to severe winters in 1995/1996 and 1996/1997 (MN DNR 2001). Furthermore, according to its 2001 Wolf Management Plan, Minnesota has, for more than 20 years, and with an ever increasing wolf population, "successfully managed deer populations at levels that have provided increasing hunter-harvests and ample prey for wolf recovery and persistence, despite variable winter conditions, highway collision losses, other predation, and other mortality factors" (MN DNR 2001, p.26). In Wisconsin, an analysis of wolf impacts on deer concluded, "it appears that habitat and climatic effects have greater impacts on deer population trends than wolf predation" (WWAC, 1999, p.58).

These studies suggest that a recolonizing wolf population would not significantly affect Utah's ungulate populations. For example, estimated predation rates obtained from intensive studies in Yellowstone (Phillips and Smith, 1997; D. Smith, 1998; D. Smith et al., 1999b), Idaho (Husseman and Power, 1999) and the northern Great Lakes Region (WWAC, 1999) which range from 12.4-18 ungulates killed per wolf per year, indicate that a population of 200 wolves should kill no more than 3,600 wild ungulates each year in Utah. Although only rough estimates of current population numbers for Utah ungulates are available, the Utah DWR winter population objectives for 2000 suggest that Utah could potentially support a mule deer population of approximately 480,000 and an elk population of approximately 74,000 (UT DNR 2001b). These population objectives are, by definition, overestimates of the actual population at any given time, but are useful in evaluating the likely impact of wolf predation. Whether or not wolf predation would constitute compensatory or additive mortality, these figures suggest that a wolf population of 200 would not significantly decrease overall ungulate populations in Utah. For comparison, it has been variously estimated that Utah motorists kill at least 2,000-5,500 (Romin and Bissonette, 1996), or more than 7000 (Messmer, 2001), deer each year. Additionally, Utah's hunters in 1999 harvested 34,433 deer and 13,188 elk (UT DWR, 2001b). It is important to note, however, that because the wolf population would not be spread evenly among all ungulate populations, wolves might have substantial impacts on

ungulates in some areas. The magnitude of these potential local impacts is difficult to predict.

4.4.2. Ungulate Behavior

Wolf recolonization, on the other hand, may influence ungulate behavior in Utah. Berger (1998) proposed that when specific predators are absent for generations, prey might lose their ability to recognize and avoid those predators, and actively defend against them. If this was the case, then recolonizing wolves might be expected to have a significant advantage over these "naïve" prey. Alternatively, prey might adjust their behavior relatively rapidly, leading to changes in group size, vigilance, or shifts in habitat use. Recently, Berger et al. (2001) found that female moose in the Greater Yellowstone Ecosystem have developed hypersensivity to wolf howls. Elk at the National Elk Refuge in Wyoming have increased vigilance and formed tighter groups (B. Smith and Berger, 2001). Additionally, when wolves hunted near the National Elk Refuge, elk routinely dispersed to other feeding grounds, where they congregated in larger numbers and may have enjoyed better visibility of approaching predators (USFWS et al., 2001). Thus, at least in these cases, ungulates have adjusted their behaviors within a single generation, suggesting that wolf restoration will not decimate naïve prey populations in Utah.

Although the Yellowstone elk herds have remained very stable throughout wolf recovery, elk may be shifting their habitat use away from high wolf-use riparian areas. Since the reintroduction of wolves in Yellowstone, large areas of riparian willow have begun to recover from overgrazing by elk. One interpretation of these data is that wolves are altering habitat use by elk, and reducing browsing on riparian willows. Wolf recovery may also aid in the restoration of aspen groves (Chadde and Kay, 1988). Researchers have discovered that most aspen groves in Yellowstone have not regenerated themselves since the 1920s, coinciding with the extirpation of wolves. Ripple and Larson (2000) hypothesize that wolves may be responsible for increasing aspen recruitment in Yellowstone in recent years by influencing elk movements and browsing patterns. Consistent with these findings, Singer and Mack (1999) predict that elk may increase their use of forest cover to escape wolves. We would expect similar changes in ungulate behavior in Utah in response to the presence of wolves during recolonization.

4.4.3. Predators and Scavengers

Wolf recovery will probably also have impacts on other predators and scavengers (e.g. Leopold, [1937] 1995). Wolf reintroduction and recovery in other areas has changed the abundance and distribution of many predators and scavengers. Through direct predation, wolves reintroduced into Yellowstone have reduced the Lamar Valley coyote population by 25% to 33% each winter (Crabtree and Sheldon 1999). Furthermore, behavioral changes have been observed in surviving coyotes (Switalski, 2002).

The reduction, displacement, and behavioral changes of coyotes may have a cascading effect throughout the ecosystem. Prior to wolf reintroduction, coyotes in the Lamar Valley annually removed 76% of microtine vole, 23% of pocket gopher, 35% of ground squirrel populations from the northern range of Yellowstone (Crabtree and Sheldon 1999). The return of the wolf has reduced predation pressure from coyotes on these

populations, and predators such as foxes, hawks, owls, eagles, badgers, and pine martens may be benefiting from additional prey availability. Additionally, displacement or reduction of the coyote population may decrease coyote predation on ungulate neonates (Singer and Mack, 1999; UT DWR, 2001b; Power, 2001), and foxes (Harrison et al., 1989). Anecdotal evidence suggests that wolves may also influence cougar and black bear behavior and populations.

Prior to wolf reintroduction into Yellowstone, scavengers relied heavily on ungulate winterkill and neonates for food. Since reintroduction, scavengers have benefited greatly from the consistent year-round supply of wolf-killed ungulates. Preliminary findings show that grizzly bears, coyotes, foxes, ravens, magpies, bald eagles, and golden eagles are all using wolf-killed carcasses, and anecdotal evidence suggests that populations of many of these species are increasing (with the exception of coyotes; C. Wilmers, Yellowstone Ecological Research Center, in preparation).

4.4.4. Conclusion

In conclusion, research is continuing to document the effects of wolf recovery on ecosystems. In addition to direct impacts, there are many indirect effects, including trophic cascades. Most of these effects are positive, and appear to be increasing overall ecosystem integrity. As wolves inevitably begin to recolonize Utah, land managers should be prepared to address these ecosystem impacts. It will be essential to monitor and research the recolonizing population. Radio-collaring and monitoring of wolves will allow managers to monitor their dispersal, distribution, proximity to livestock, and aid in law enforcement, as well as determining wolf habitat use, seasonal food habits, predation rates, breeding and denning activity, causes of wolf mortality, corridor use, and overall effects on Utah's ecosystems. We recommend that, in addition to monitoring the wolf population, the state of Utah begin a comprehensive program to monitor ungulate populations. This will allow not only an assessment of how wolves may be impacting those populations, but may also improve ungulate management in general, and thereby overall habitat quality.

5. Economic Aspects of Wolf Recolonization in Utah

An assessment of likely economic effects of wolf recovery should be included in the discussion of the future of wolves in Utah. In this section, we discuss both the potential benefits and the expected costs of wolf recovery to Utah's economy. The potential benefits include both use—such as increases in tourism resulting from the presence of wolves—or non-use values that can be measured by willingness to pay surveys. The expected costs of recovery include direct costs born by agencies involved in wolf management, livestock owners that experience losses from wolf depredation, and those that might result from reduced game take by hunters. In addition, there may be indirect costs, which are more difficult to quantify.

5.1. Potential Benefits of Wolf Recolonization

5.1.1. Tourism

Tourism is one of Utah's top five economic activities, generating $4.25 billion in revenues in 2000, and the majority of visitors come to Utah to engage in outdoor recreation (UT DTD, 2001). Wolf recovery might have a beneficial impact on tourism in Utah as it has in other states where wolves have been reintroduced or have recolonized. An estimated 20,000 people viewed wolves in Yellowstone during the first two and a half years after they were reintroduced (D. Smith et al,. 1999a). Furthermore, the three-year average of entrance receipts from Cooke City, which is the best park access point for viewing wolves, has increased by nearly 25% following reintroduction (Gaillard et. al., 1999). These findings might not be entirely applicable to Utah, as they are confounded by the presence of Yellowstone National Park itself. For example, potential areas for wolf recolonization in Utah may not share the unique characteristics of Yellowstone (e.g., relatively open terrain). However, at least one study suggested there could be an increase in tourism associated with red wolf recovery in North Carolina, where the primary land cover is relatively dense pine forest. Rosen (1997) found that 70% of the people surveyed expressed more interest in visiting northeastern North Carolina because wolves were present. It was also estimated that tourism in the region would increase, resulting in increased revenues of $9.2-$21.1 million (Rosen 1997). These studies suggest that the presence of wolves might also have beneficial impacts on the tourism industry in Utah. Wolf Education Centers, if properly designed and marketed, could also generate substantial revenue. For example, the International Wolf Center in Ely, Minnesota, generates average annual revenues of $3 million (Mech, 1998).

5.1.2. Preservation Value

Another way to quantify the economic benefit of wolf recovery is the "preservation value" of wolves. This is manifested through a person's willingness to contribute toward preservation of wolves and their natural habitats both for current viewing and for future generations (Loomis, 1993). The dichotomous choice contingent valuation method is a survey technique that constructs a hypothetical market to measure willingness to pay (Loomis, 1993). Duffield and Neher (1996) used this method to estimate the public's willingness to pay for wolves in Yellowstone. Visitors to the Park were asked whether they were in favor of, or opposed to, wolf reintroduction in Yellowstone and whether

they would donate varying dollar amounts for trust fund membership to support or oppose reintroduction (Duffield and Neher, 1996). The responses were analyzed and an average amount was estimated for support or opposition. On average, each person would give $22.87 for a one-time donation to a trust to support wolf recovery. We hesitate to assign these benefits to Utah because those surveyed in the study may have strongly associated wolves with their Yellowstone experience and may not have been assigning a dollar value for wolves themselves. While the presence of wolves in Utah may augment visitor experiences, people who are willing to pay a certain amount for wolves in Yellowstone may or may not be willing to pay the same amount for wolves in Utah.

We were unable to conduct a full economic analysis of wolf recolonization in Utah and are therefore unable to provide more reliable estimates of potential economic benefits. However, there is ample evidence from other areas that such benefits exist. We recommend that a comprehensive economic analysis, which explicitly examines potential benefits, be conducted as part of any planning process. Such an analysis would greatly facilitate a serious discussion of the economic impact of wolf recolonization.

5.2. Expected Costs of Wolf Recolonization

5.2.1. Management Costs

Direct costs will be incurred by the agencies involved in implementing management policy for wolves in Utah. These costs may vary depending on how wolves arrive in Utah. Since Montana, Wyoming, and Idaho have not yet developed state management plans, no data on state management costs are available for the Rocky Mountain region. Therefore, we have attempted to estimate direct management costs for Utah using data from existing and proposed management plans in Minnesota and Wisconsin.

The Minnesota Department of Natural Resources (MN DNR) recently submitted a wolf management plan budget for approval from the state legislature (MN DNR 2001). The estimated annual ongoing costs of the plan are $695,000 (Figure 5). Law enforcement and depredation combined constitute the largest share of the budget at 60%.

Currently, Minnesota has more than 2,500 wolves. It is highly unlikely that Utah will ever have more than several hundred wolves. On the other hand, Wisconsin has estimated costs for managing approximately 200 wolves. The annual state and federal funds expended for wolf management in Wisconsin from 1979 to 1998 averaged $21,481 and $59,959, respectively. The annual management cost per wolf in Wisconsin has averaged approximately $2,300 for the period from 1979 to 1998. This cost has decreased as the number of wolves has increased (the estimated current cost per wolf is $660), although the total management cost has increased. Consistent with this, in Minnesota, with its 2,500 wolves, management costs per wolf are much lower, approximately $265 annually.

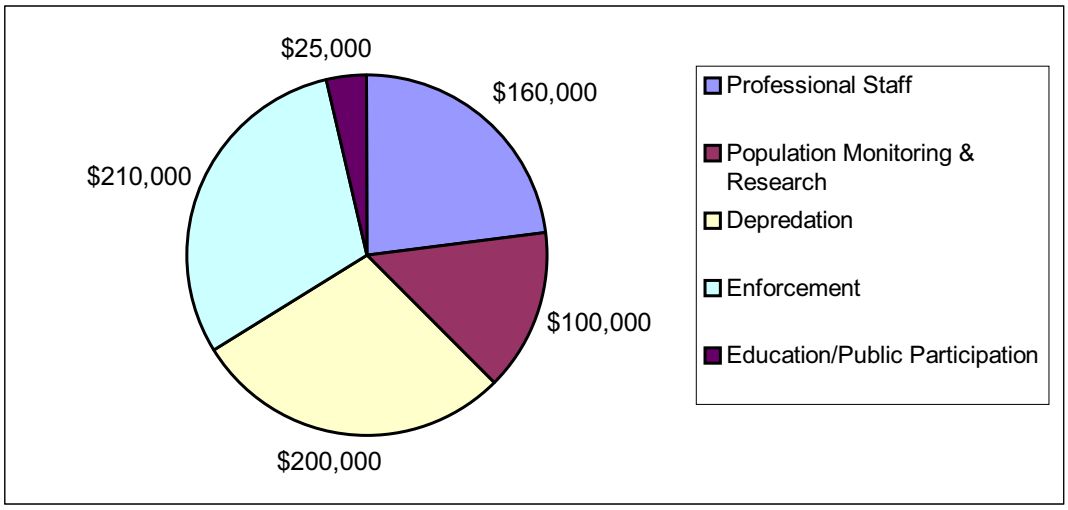

Figure 5. Proposed budget for wolf management in Minnesota (MN DNR, 2001).

Estimated total state and federal costs for wolf management in Wisconsin are $130,000 for fiscal year 1999-2000 and were expected to increase about 10% per year each year thereafter (WWAC, 1999). One third of the $130,000 is allocated toward the salary of a program director. This suggests that the low number of wolves predicted for Utah would not necessarily lead to substantial management costs for either state or federal agencies. If we assume that the current Wisconsin costs ($660 per wolf) are applicable to wolves in Utah, and that the Utah wolf population never exceeds 200 animals (see Section 4.2.), then total management costs should never exceed $130,000 per year. However, we recognize that differences between Utah and Wisconsin (e.g., topography, livestock production practices, and the distribution of wolf habitat) may affect the accuracy of these estimates for Utah. In any case, means for reducing overall costs can be implemented. For example, in Wyoming, the use of volunteers for monitoring wolf populations is currently decreasing the cost of wolf management (Jimenez, 2001).

Control of problem wolves is another management cost that will be experienced in Utah, although it is included in the estimates above. In Minnesota, 161 out of an estimated population of 2,500 (6%) were killed in response to damage complaints (for example, livestock or pet depredations) in 1998 (Paul, 1999). In contrast, in the three states of the Northern Rockies Recovery Area, an average of 4.4%-9.6% of the wolf population has been controlled (e.g., capture, relocation, or killing of problem wolves) annually since 1987 (E. Bangs, USFWS, personal communication; USFWS et al., 2001). The average percent controlled varies depending upon how exactly the calculation is performed, as wolves killed are often the same ones moved (E. Bangs, USFWS, personal communication). Using these numbers, we would estimate that, on average, between 9 and 19 wolves would be controlled annually in Utah, assuming a wolf population of 200 animals.

5.2.2. Direct Livestock Depredation Costs

Perhaps the most contentious potential economic impact of wolf recolonization is the potential loss of livestock to depredation. In areas where wolves have been reintroduced, the data have shown that wolves choose to prey primarily on deer and elk populations (USFWS et al., 2001). However, wolves will kill livestock. The two aspects that need to be considered are the direct losses resulting from the depredations and the cost of any compensation program that might be implemented. We have attempted to estimate these costs using data from other states that have both wolves and livestock in combination with relevant data on the Utah livestock industry.

In 1999, 1.4% of cattle losses (200 head) and 3.8% of calf losses (1,000 calves) in Utah were from predators (UASS, 2000), as shown in Figures 6 and 7. These predators included coyotes, black bears and mountain lions. Using 1999 values ($660 per head of cattle and $290 per calf), total cattle and calf losses due to depredation in Utah were $417,000. It is difficult to determine how these predation losses may change if wolves return to Utah.

Much concern has been expressed regarding possible increases in cattle losses in Utah due to wolf depredation. However, there are very few recorded instances of wolf depredation on healthy adult cattle (Paul, 1999; Niemeyer, 2001). In fact, no wolf depredations on adult cattle have been confirmed in the 25 years that wolves have been recolonizing Wisconsin (WWAC, 1999; Jurewicz et al., 2000), and Minnesota's 2,500 wolves kill fewer than an average of 10 adult cattle and yearlings per year (Paul 1999). In Alberta, which has more than 5,000 wolves, an average of 21 adult and yearling cattle were killed by wolves annually between 1974 and 1980 (Gunson, 1983). In the three

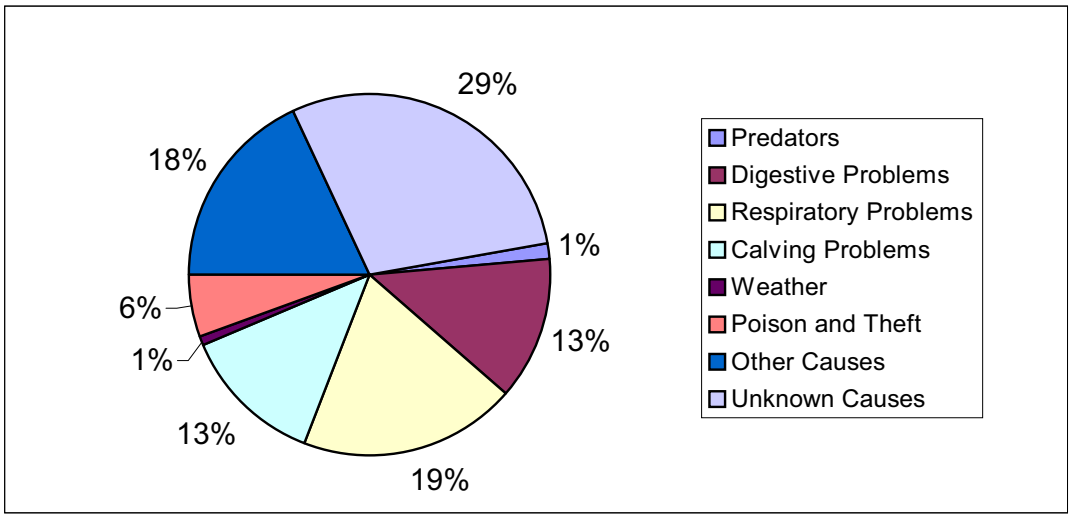

Figure 6. Causes of death for adult cattle lost in Utah during 1999. Predators were responsible for 1% of total losses (UASS, 2000).

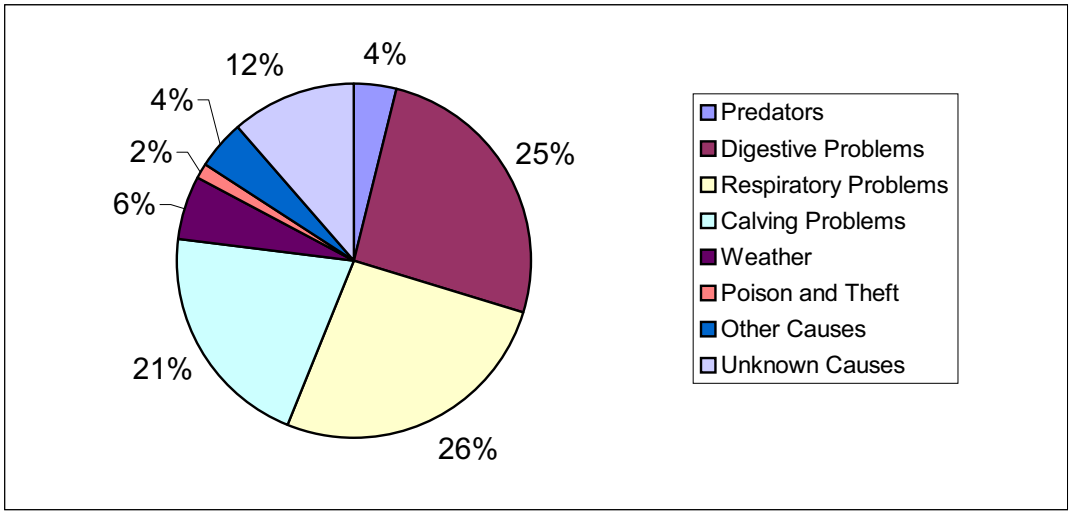

Figure 7. Causes of death for calves lost in Utah during 1999. Predators were responsible for 4% of total losses (UASS, 2000).

states of the Northern Rockies Recovery Area, according to Defenders of Wildlife (2001a), fewer than two depredations on adult cattle have been compensated each year since 1987. However, according to the USFWS, there have been a total of only two confirmed depredations on healthy adult cattle during that time (J. Fontaine, USFWS, personal communication) Given these data, we would expect very few depredations (averaging < 2 annually) on adult cattle in Utah. At 1999 prices ($660 per animal), this corresponds to an additional annual loss due to wolf predation of $1,320 (see Table 2).

On the other hand, we do expect to see an increase in calf losses, as wolves preying on livestock are known to selectively attack calves (Gunson, 1983; Fritts et al., 1992). In the year 2000, for example, the 433 wolves in Montana, Wyoming, and Idaho killed a confirmed total of 32 cattle (all calves and yearlings; USFWS et al., 2001; J. Fontaine, USFWS, personal communication), whereas in 2001, with a population of 572 wolves, there were 35 confirmed depredations on cattle (E. Bangs, USFWS, personal communication). We used these numbers to estimate likely losses of calves to wolf depredation in Utah, assuming a wolf population of 200. Of the 572 wolves in the Northern Rockies Recovery Area in 2001, only approximately 340 had regular

Table 2. Estimated Direct Livestock Depredation Costs in Utah with a Wolf Population of 200 (1999 Dollar Value and Livestock Prices)

Type of Livestock	Number of Losses	Estimated Cost
Adult Cattle	2	$1,320
Calves	116	$33,720
Sheep and Lambs	200	$39,000
Estimated Total Direct Losses	**288**	**$74,040**

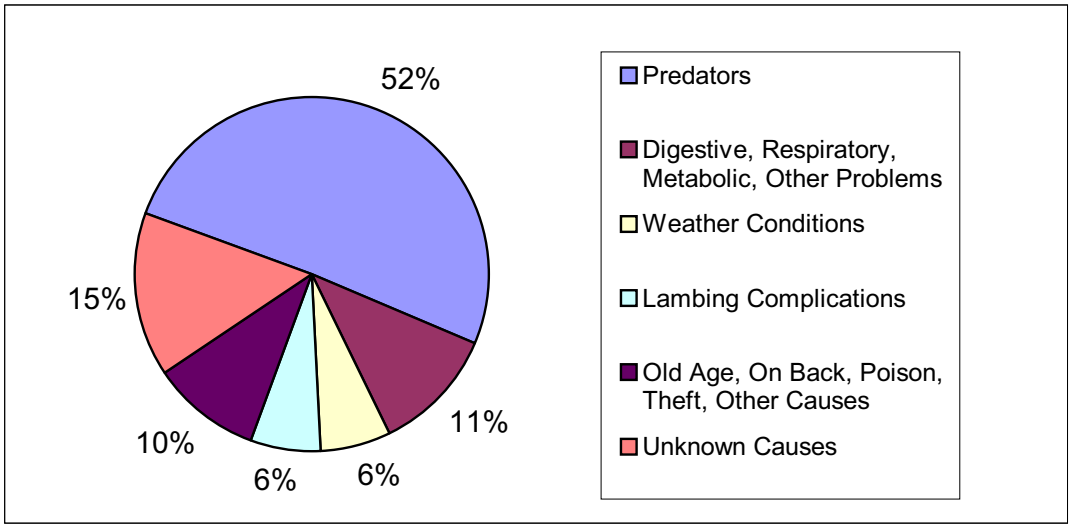

Figure 8. Causes of death for sheep and lambs in Utah during 1999 (UASS, 2000). Predators were responsible for 52% of total losses.

contact with livestock (E. Bangs, USFWS, personal communication). Therefore, we used this lower number to calculate a per wolf depredation rate (0.102/wolf). Because actual depredations are generally higher than confirmed depredations, we adjusted this number using the results of a recent study that found a ratio of actual:confirmed depredations of 5.7:1 (USFWS et al., 2001). Although this may still be an underestimate of the true number of depredations, it suggests that actual losses of calves to wolves in Utah should be less than 116 per year**.** At 1999 prices ($290 per calf), this corresponds to a maximum additional annual loss of approximately $34,000 (see Table 2).

Predators were responsible for 52% of the sheep and lamb losses in 1999 in Utah (see Figure 8), or approximately 34,000 animals (UASS, 2000). Using a 1999 value of $99 per head, total sheep and lamb losses due to depredation in Utah were approximately $3.4 million. In the year 2001, 132 sheep and lambs were confirmed killed by wolves in Montana, Wyoming, and Idaho (Ed Bangs, USFWS, personal communication). Since wolf recovery began in the northern Rockies, this number has fluctuated between 0 and 132 annually. Once again, this is certainly an underestimate of actual losses to wolves. Connolly (1992) estimated that, nationwide, 19% of reported depredations on adult sheep and 21% of depredations on lambs are confirmed by United States Department of Agriculture Wildlife Services.

Using these numbers, we estimated that a wolf population of 200 would kill approximately 385 sheep and lambs annually. We arrived at this figure by assuming that only 20% of reported losses of sheep and lambs in the northern Rockies were confirmed as killed by wolves. We further assumed that a wolf population of 200 wolves would kill at about the same rate as the 340 wolves in the northern Rockies that regularly contact

livestock. At 1999 prices ($99 per animal), this corresponds to an additional loss of approximately $39,000 statewide due to wolf predation (see Table 2). Wolves may not prey selectively on lambs relative to adult sheep (Gunson, 1983), so we have not considered them separately in our loss estimates. We recognize that differences exist between Utah and these other states (e.g., size of operations, differences in management, and/or environmental circumstances), so these estimates are approximate. Nevertheless, it is clear that, even with a relatively large wolf population (200), impacts on the Utah livestock industry as a whole are likely to be relatively minor. In fact, it is possible that overall losses to predation would actually decrease following wolf recolonization, as a result of the effects of wolves on other predators. For example, a substantial reduction in coyote numbers, as has occurred in Yellowstone, might reduce total predation on sheep (see Section 4.4.3). We recognize that impacts on individual producers may be significant, however.

5.2.3. Indirect Livestock Depredation Costs

In addition to the direct costs arising from wolf depredation on livestock, there are a number of potential indirect costs. They may include costs associated with the time required for locating and obtaining verification of kills, losses of investments in selected breeding lines, loss of future offspring, increased time and labor to recover predator-dispersed flocks or herds, underutilization of some potential foraging sites and excessive degradation of others, stress-related changes in animal body condition, and decreases in pregnancy percentages and weaning weights (Wagner, 1988; Stricklin and Mench, 1989; W. Urie, Utah Farm Bureau Federation, personal communication). These indirect costs are difficult to quantify, and few data are available that address these issues. Therefore, we recommend that a study be conducted to measure the magnitude of indirect costs arising from wolf depredations.

In addition, concern has been expressed regarding a possible increase in the cost of predator control in wolf-recolonized areas. Some temporary restrictions on trapping or other predator management techniques are likely to occur in some areas and might lead to increased control costs. For example, restrictions on M-44s (spring-loaded sodium-cyanide delivery devices) and neck snares in wolf-occupied areas might require more expensive aerial gunning for coyote control (Bodenchuk, 2001), although studies have shown that coyote populations are depressed in areas recolonized by wolves (see Section 4.4.3.). Finally, there may be costs associated with implementing techniques to minimize depredation. Such costs might include increased fencing, additional guard animals, or additional range riders, for example. However, some of these costs are being subsidized in the Northern Rockies Recovery Area by conservation groups involved in wolf recovery.

5.2.4. Wolf Depredation Compensation Programs

One approach to reducing the financial impacts of predator depredations on livestock has been the establishment of compensation programs that pay ranchers for depredated livestock (Wagner et al., 1997). Currently, Defenders of Wildlife, through the Bailey Wildlife Foundation Wolf Compensation Trust, pays compensation for confirmed and probable losses of sheep, cattle, and pets that result from wolf depredation. The goal of

this Trust is "to shift economic responsibility for wolf recovery from the individual rancher and toward the millions of people who want to see wolf populations restored" (Defenders of Wildlife 2001a). Accordingly, the Compensation Trust, using donations from private citizens across the country, pays fair market value for depredations confirmed by USDA Wildlife Services personnel, and 50% of fair market value for probable depredations.

Payments made to ranchers in 2000 for both probable and confirmed livestock losses in Wyoming, Idaho, Montana, Arizona, and New Mexico totaled $50,446.25. This included payments for 36 cattle and calves, 105 sheep, and 13 other losses (mostly dogs). Since the program's inception in 1987, payments have totaled $156,608 for 185 cattle and calves, 401 sheep, and 24 other animals (Defenders of Wildlife, 2001a, 2001b). In Minnesota, the Department of Agriculture has established a state-funded compensation program that pays "fair market value" to producers for confirmed wolf depredations, although payments are capped at $750 per animal (raised from $400 in 1998). Compensation payments under this program ranged from $31,000 to $67,437 per year from 1993-1998 (MN DNR, 2001). In 1998, under the new $750 limit, 99 farms, out of a total of approximately 8,000 in wolf range, received compensation payments totaling $67,437 for losses of cows, sheep, turkeys, and other animals (Paul, 1999).

Utah will also require some form of compensation program to help reduce animosity and promote cooperation among livestock producers, managers, and wolf advocates. Defenders of Wildlife has indicated that they may compensate any wolf depredation that occurs in Utah, at least while wolves retain endangered or threatened status. Although this assistance will be helpful in the short term, a long-term solution that does not depend on donations may be required. A state-funded compensation program, modeled after those established in Minnesota and Wisconsin (Jurewicz et al., 2000, MN DNR, 2001), is probably the most appropriate way to address this requirement. Based on the depredation rates and loss estimates derived above for a population of 200 wolves, direct compensation payments should not exceed $46,320 annually, not including administrative costs.

These estimates do not include indirect costs. To adjust for this, we suggest that any state compensation program include supplemental payments, the magnitude of which should be determined after a thorough and ongoing analysis of potential indirect costs. In the short term, we suggest that the state of Utah establish a supplementary compensation program to complement the Defenders of Wildlife program. Although there is no precedent for such supplementary compensation, either for wolf predation elsewhere in the country or for other predators such as lions and bears in Utah, we believe that it is important for several reasons. First, it sends a credible message to ranchers that indirect costs are legitimate. Second, it recognizes that opportunities for the utilization of current forms of predator control may be limited because of the special legal status of wolves. And finally, it may be an effective method of reducing (not eliminating) animosity toward wolves, and thereby minimizing illegal killing.

5.2.5. Potential Effects on Hunting
There is concern in the Utah hunting community that wolves will destroy big-game populations (e.g., Peay, 2001b), and reduce the economic benefits associated with hunting. However, as reviewed above (see Section 4.4.1.), there is little evidence suggesting that managed wolf populations would significantly affect Utah's ungulate populations. For example, the 2000 Gardiner, Montana, late elk-hunt harvest of the northern Yellowstone herd was slightly above average, and hunter success was 63% (compared with the 25-year average of 65%), despite the presence of a rapidly increasing wolf population in the area (MT DFWP 2001).

A more realistic concern for hunters, however, may be increased dispersal of ungulate populations in areas occupied by wolves, and a corresponding increase in hunting effort required to fill a permit, resulting in hunter frustration, and possibly decreased revenues for outfitters whose designated permit area is disrupted by wolves. It is possible that this might result in localized economic impacts, especially if hunters abandon these areas. It is difficult to estimate the magnitude of these potential economic impacts. We are aware of only a single study that addresses these issues. Prior to wolf reintroduction, it was estimated that the loss of expenditures in the Greater Yellowstone Ecosystem (GYE) due to reduced hunting opportunities would be $207,000-$414,000, and the lost net social benefits would be $187,000-$465,000 (Duffield and Neher, 1996). A recent study, however, has found that no actual economic losses have occurred since wolf reintroduction in the GYE (Brown et al., 2000). In summary, the limited evidence suggests that wolf recolonization does not have to affect either hunting success itself, or the economic benefits associated with hunting.

5.3. Alternative Funding Sources
Although wolf management and compensation programs may represent new costs for the state of Utah, there may be ways to offset these costs. Possible revenue sources that have been utilized in other states to fund nontraditional wildlife management programs include dedicated taxes, themed license plate and stamp sales, state lotteries, and state tax check-offs. Arizona, for example, has a $10 million annual dedication from the state lottery to fund nongame wildlife management. Collaboration with nongovernmental organizations and other private entities should be sought wherever possible, as such organizations bring a constituency and a willingness to pay for wolf recovery. For example, the Turner Endangered Species Fund, founded by Ted Turner, has been instrumental in facilitating wolf recovery in the northern Rockies by providing facilities, personnel, and research funds. Similar programs, if implemented in Utah, could significantly reduce costs to state agencies after de-listing. It is also possible to secure federal assistance pursuant to section 6(c) of the Endangered Species Act. Finally, once a viable population is established and wolves are de-listed, a limited trophy hunt on wolves might be possible with permit fees dedicated to offset management costs.

5.4. Conclusion
Although there is much to be learned from the experiences of other states, each situation is unique, and Utah will be no exception. For that reason, we feel there is a compelling argument to be made for a comprehensive analysis of the probable economic benefits and

costs of wolf recovery in Utah. Such an analysis may reveal that tangible economic benefits are likely to result, perhaps as a result of increased tourism, but through other avenues as well. Other nontangible benefits, such as willingness to pay benefits, should not be overlooked, but rather used as a starting point from which real economic benefits might flow, given a thoughtful and creative planning process. On the other hand, the potential costs of wolf recovery are much easier to quantify, as they largely arise from issues such as livestock depredation that may be more directly analogous to what has happened in other areas. Even so, an in-depth analysis that focuses specifically on Utah may reveal significant differences in probable costs as compared with other states. In any case, the analysis would provide a common set of agreed-upon data that all stakeholders could use.

One conclusion of our brief analysis is that livestock depredations and impacts on ungulate populations may not be as problematic on a regional scale as is often assumed, although local impacts could be more significant. This is not meant to trivialize the important concerns that many people in Utah have about wolves, but to suggest that the actual number of livestock depredations attributed to wolves in Utah may be relatively low. Additionally, deer and elk populations in Utah may not be significantly affected by wolves. That these issues remain contentious merely underscores the need for a comprehensive economic analysis that addresses the concerns of all stakeholders interested in wolf management.

6. Potential Strategies for Managing Utah's Wolf-Livestock Conflicts

6.1. Overview

The United States Fish and Wildlife Service (USFWS) classifies gray wolf populations as either endangered, threatened, or nonessential/experimental. Therefore, if wolves enter Utah under their current legal classification, the USFWS will be the primary agency responsible for wolf management (see Section 2). For the last 30 years, this agency has been responsible for managing recovering wolf populations in other parts of the United States, both in the Great Lakes and the Rockies. Unfortunately, wolves have come into conflict with livestock in all of their recovery areas. As a result, the USFWS has taken various measures to minimize these conflicts, while maintaining their objectives to continue to recover wolf populations.

Some of the measures the USFWS has implemented in the Northern Rockies Recovery Area for reducing wolf-livestock conflicts include (1) drafting the Interim Wolf Control Plan (IWCP) (USFWS, 1988) to serve as a guideline for controlling problem wolves in the northern Rockies; (2) classifying wolves in the Greater Yellowstone and Idaho Recovery Areas as nonessential/experimental populations, which prompts wolf management regulations under separate experimental population rules (Federal Register Vol. 59. No. 224) and allows for more liberal management of problem wolves; and (3) cooperating with the U.S. Department of Agriculture/Animal and Plant Health Inspection Service/Wildlife Services and wolf interest groups (Defenders of Wildlife and Turner Endangered Species Fund) for better wolf depredation management.

The cornerstone of any Utah wolf management plan will clearly be developing strategies for minimizing wolf-livestock conflicts, and instituting mechanisms for dealing with those that do occur. Niemeyer et al. (1994) advocated the protection of rural interests, promotion of public tolerance, and responsible management and protection for wolves as key elements in a wolf management program. Responsible wolf management ensures that the resolution of wolf-livestock conflicts meets the interests of livestock producers, natural resource managers, and the general public. The number of states that have dealt with wolf-livestock conflicts has increased dramatically since wolves were put on the endangered species list in the early 1970s. Originally, Minnesota was the only state that had to address wolf-livestock conflicts; this has now expanded to include Wisconsin, Michigan, Montana, Idaho, Wyoming, Arizona, and New Mexico. We have gleaned information from existing wolf management plans from around the U.S. and from the literature and here offer guidelines for preventing and reacting to wolf-livestock conflicts (e.g., MGWRT, 1997; WWAC, 1999; ID LWOC, 2000; MN DNR, 2001; MT DFWP, 2001). In general, we recommend a two-pronged approach: (1) preventing wolf depredations on livestock and (2) implementing wolf control.

6.2. Preventing Wolf Depredations on Livestock

A number of techniques have been used to minimize livestock depredation; however, they vary widely in effectiveness, selectivity, and humaneness (Cluff and Murray, 1995). Even effective techniques are not applicable in every situation, and therefore effective

predator deterrence requires an integrated approach (Fritts et al., 1992). Some of these methods have only been studied for their effectiveness in deterring predation by coyotes (Wagner, 1988; Cluff and Murray, 1995; and Knowlton et al., 1999), and so their ability to deter wolf predation has not been determined. However, coyotes and wolves share many morphological, behavioral, physiological, and sensory attributes, and therefore the results from studies on coyotes may be applicable for wolves as well, at least in some cases. In addition, various agencies and interest groups are currently testing new techniques, which, although they may prove to be effective, are not reviewed here. With this in mind, the following techniques may minimize wolf depredations on livestock in areas where wolves and livestock may coexist in Utah.

- **Altering livestock husbandry practices.** Adjustments in livestock-rearing practices can be beneficial for the protection of livestock from predators, although their effectiveness varies depending on the size and location of pastures and type of livestock. Preventative methods include:
  - Removing livestock carcasses promptly from grazing lands.
  - Calving or lambing in a confined area (e.g, a fenced pasture), to reduce mother-offspring separation and therefore vulnerability of neonate livestock (Wagner, 1988).
  - Stricter human vigilance or closer proximity (e.g., herding) to livestock herds (Davenport et al., 1973a, 1973b), especially during lambing and calving.
  - Adequate fencing when possible, including antipredator electric fencing (Gates et al., 1978; Linhart et al., 1982; Acorn and Dorrance, 1994), to keep predators out of livestock areas.
  - Synchronized lambing and calving to reduce the period of maximum vulnerability in lambs and calves (Knowlton et al., 1999).
- **Using livestock guarding dogs.** For centuries, some breeds of domestic dogs have been bred specifically for the protection of livestock (e.g., Hungarian Komondor and Great Pyrenees). Although they are known to be helpful in minimizing predation by coyotes, little empirical evidence is available demonstrating that livestock-guarding dogs mitigate wolf depredation in the United States (e.g., Coppinger and Coppinger 1995). However, M. Smith et al. (2000) discuss potential strategies for using livestock-guarding dogs effectively with wolves. For coyotes, livestock-guarding dogs work by being attentive to livestock and fending off intruders (McGrew and Blakesley, 1982), whereas for wolves these dogs may establish territories excluding wolves, or may distract wolves and disrupt their normal predatory sequence (M. Smith et al., 2000). It should be noted that few, if any, guard dogs specifically trained to defend livestock against wolf depredation have been used in the United States. Such training might increase the effectiveness of guard dogs in reducing wolf depredations.
- **Relocating livestock into other grazing lands.** It is possible that in some areas livestock will graze in habitats where the management of wolves will be biologically or politically difficult. Therefore, in these cases, it may be beneficial to move

livestock to other grazing areas where the risk from wolf depredations will be smaller or non-existent, or where wolves can be more easily managed.

- **Relocating wolves into other areas or stocking grazing lands with native ungulates.** It is also possible that in some areas livestock may graze in habitats where they may be the most abundant large prey species for wolves. In these cases, removal of wolves might be the best approach. For example, the USFWS recently relocated Yellowstone's Boulder Mountain wolf pack when they denned near a private grazing operation. On the other hand, if the continuing presence of wolves in such an area is the preferred policy, then stocking with native ungulates might reduce the impacts of wolf depredation on livestock. This was recommended for reducing wolf depredations on livestock in northern Portugal, where native ungulates were at very low densities and livestock production was intensive (Vos, 2000). However, given the limited evidence, it is difficult to determine how effective this approach might be for Utah.

6.3. Implementing Wolf Control

In 1999, the revised Interim Wolf Control Plan (IWCP) defined wolf control as the

> (a) application of aversive conditioning techniques to problem wolves; (b) capturing problem wolves on Federal, state or private lands, radio tagging and releasing them on site; (c) relocating problem wolves to remote areas; (d) placing problem wolves in captivity; or (e) killing problem wolves. (USFWS, 1999, p.4)

In order to minimize depredation events following wolf recolonization in Utah, it is vital that a well-planned wolf control program be ready for pending conflicts between wolves and livestock. The IWCP elucidated this argument very convincingly, not only for the northern U.S. Rocky Mountain region but also for any area that has the potential for wolf-livestock conflicts to occur:

> Application of a practical, responsive management program including control is essential to the recovery effort. Implementation of a control program will enhance the general survival of the wolf by showing that responsible Federal agencies will act quickly to resolve depredation problems. Timely response to depredations will alleviate the perception of Government inaction that often results in landowner frustration, which, in turn, may lead to the indiscriminate killing of wolves. Removal of problem animals does more than stop the depredation. It relieves the pressures or antagonisms directed toward the total population by the landowner(s) incurring the losses or other members of the public. Consequently, the local (wolf) population is in less danger from potential nonselective illegal attempts at damage control. In addition, control actions will focus on control of problem wolves and, in doing so, will resolve wolf/human conflicts through removal of a minimum number of wolves. Based on the low rates of livestock depredation in northwestern Montana and the availability of ungulate biomass, the number of wolves killed under this wolf control strategy is not likely to impede overall recovery efforts though temporary reductions in local areas may occasionally occur, as in 1997. The Service's biological opinion on the draft Control Plan,

> August 5, 1988, concluded that the proposed action is not likely to jeopardize the continued existence of the wolf. The biological opinion on the modified Control Plan, July 22, 1999, reached the same conclusion. By enhancing the survival chances of those non-offending wolves and removing those wolves that do kill livestock, the control program will contribute to the ultimate recovery of the wolf in . . . the Rocky Mountains. (USFWS, 1999, p.6)

Until the USFWS decides that another agency is responsible, we assume that they will be the primary agency for wolf management in Utah. Furthermore, Wildlife Services has provided wolf control specialists for other wolf recovery areas. Therefore, for the purpose of these recommendations we have assumed that they will continue these services. We recommend a two-step approach for wolf control actions. These recommendations are similar to those in the IWCP. First, it is necessary to identify whether or not wolves are responsible for a given depredation event. If wolves are found to not be responsible, then no wolf control action should take place. If wolf involvement is verified, then conducting wolf control actions will be necessary.

Verification of Wolf Involvement

- Efforts should be directed toward locating, capturing, radio-collaring, and monitoring of wolves in Utah. Intensive monitoring of radio-collared wolves would assist wolf control personnel in anticipating conflicts and in locating depredating wolves. Telemetry information would inform agency personnel of any collared wolves that are in close proximity to a site where livestock were damaged or killed.

- Trained specialists from appropriate agencies should be responsible for prompt responsiveness (within 48 hours) to reports of wolf/livestock or wolf/pet conflicts.

- To ensure proper verification, wounded livestock or remains of a livestock carcass should be present with clear evidence that wolves were responsible for the damage.

- Before initiating wolf control efforts, there should be reason to believe that additional losses would occur in the absence of wolf control.

- Before initiating wolf control efforts, animal husbandry practices should be verified as being reasonably responsible ("best management practices") for reducing losses to wolves.

Conducting Wolf Control

- It is difficult to offer recommendations for wolf control without clear population objectives for wolves in Utah. Once population objectives have been defined, then recommendations for control should mesh with those management objectives.

- Any non-lethal control, trapping, relocating, or killing of wolves should be conducted by authorized personnel from either the USFWS, Wildlife Services, tribes, and/or other cooperating Utah, tribal, and federal agencies.

- In the northern Rockies, the IWCP recommends that control efforts should be selective for individual problem wolves only, as opposed to local populations. Efforts are restricted to within one mile of the depredation site or to identified activity centers where the probability of capturing the problem animal(s) is maximized within a 10-day period. If depredations reoccur in the area within three months, then control efforts are conducted for up to 21 days. Although it is not possible to predict how effective these particular parameters may be for Utah, we recommend as a first step that Utah adopt similar guidelines for wolf control actions.

- When efforts to use non-lethal techniques fail or are not desirable and depredations continue, lethal control should be used according to USFWS guidelines.

- Areas in which problem wolves are to be released or relocated should be decided by the USFWS with consent from the proper land management agencies or landowners. Relocated wolves should be radio-collared, permanently marked, and monitored.

- There should be some flexibility for non-agency personnel (e.g., individual ranchers) to control wolves if they are frequenting livestock or domestic animal areas and represent a threat as determined by wolf control specialists. For example, permits for the lethal take of depredating wolves could be issued to livestock producers when USFWS and Wildlife Services have not adequately prevented further depredations. Wolf control specialists should evaluate these on a case-by-case basis.

6.3.1. Wolf Control Techniques

Wolf control techniques fit into one of two categories: non-lethal or lethal. Below we list various techniques that have been used by other wolf control specialists in North America and that should be appropriate for Utah too.

Non-lethal

- **Aversive agents.** Aversive agents induce a physiological illness in a predator after attacking livestock, producing a learned avoidance by the predator against future attacks (Wagner, 1988). For example, researchers have conducted captive and field studies using taste aversion with lithium chloride (LiCl), a substance that induces vomiting once consumed. Results were mixed and difficult to apply in a field setting (Gustavson et al., 1982; Conover et al., 1977; Burns et al., 1984). In

2001, there were no aversive agents registered by the Environmental Protection Agency for mammalian predators.

- **Light and sound repellents.** Repellents are different from aversive agents, in that they don't require a learned avoidance, but rather rely on a novel disturbance that irritates specific sensory systems to repel predators away from livestock. Strobe lights, propane exploders, sirens, and recorded sounds all have been tested with coyotes and recently with wolves. Light and sound repellents work by discharging a novel frightening-stimulus (Linhart et al., 1984), scaring away intruding wolves. Results have been ambiguous when tested on wolves in Minnesota (Fritts, 1982). Further research on these devices is being conducted in Montana by the USFWS, in cooperation with Wildlife Services and the Turner Endangered Species Fund. These techniques have been shown to be effective in the short term, but habituation may reduce their effectiveness in the long term.
- **Other techniques.** Relocation of problem wolves may also be a non-lethal control technique (see Section 6.2). Additionally, aversive conditioning is currently being tested by the Turner Endangered Species Fund. Furthermore, many ranchers in the northern Rockies are authorized to use non-lethal munitions, including "bean bags," rubber bullets, and "cracker" shells, to harass potentially depredating wolves.

Lethal

- **Traps and snares.** Foothold traps and foot snares do not kill animals and require a specialist to kill or release the animal once it has been caught. Neck snares can be set to kill an animal by strangulation. They can also be set to capture an animal by placing a stop on the snare that restricts closure of the cable. Trap tranquilizer devices have been developed to reduce foot injuries to wolves captured in foothold traps (Sahr and Knowlton, 2000).
- **Aerial gunning.** Since wolves are difficult to locate on the ground, aerial shooting has been used occasionally as a selective method for removing livestock-killing predators (Connolly and O'Gara, 1988).

6.4. Conclusion

When wolves recolonize Utah, some conflict with livestock producers is inevitable. Although we do not expect to see significant wolf depredations on livestock in the near future, a proactive, integrated approach to reducing any conflicts will be necessary if wolves are to be accepted, not only by livestock producers but also by members of the general public who may share their antipathy. None of the techniques we discussed has been shown to be 100% effective. Instead, each should be thought of as "one tool in the toolbox." A concerted effort to evaluate how and when to apply various methods should facilitate the development of a successful, cost-effective program to minimize livestock losses. On the other hand, when depredations inevitably occur, it will be just as important to have in place an effective program for controlling problem wolves. Such a program should include a full range of management options that will be implemented in a timely

fashion, and involve a concerted effort to involve livestock producers in each step of the process.

7. Education and Public Involvement

7.1. Wolf Education Programs

The goals of a Utah wolf education program should be to provide science-based, factual information about wolf ecology and management. Wolf management issues are likely to be highly publicized and volatile, and it is important that the information being disseminated is accurate and consistent with the goals of the agencies involved. Educational programs should be multifaceted and address all of the relevant issues. We recommend a program that educates the public about wolf-related issues and concerns in Utah in order to compliment viewpoints based on common myths (both pro and con), as well as on personal opinions, experiences, and biases. If such a program is implemented, people should become more knowledgeable and objective about wolves and wolf management in Utah.

We recognize that particular audiences have unique educational needs. For example:

- Campers should know what to do to prevent negative interactions with wolves and how to avoid attracting wolves to their campsites.
- Hikers may want to be able to identify wolf tracks and howls.
- Hunters will need to know what they can do when they encounter a wolf.
- Ranchers will need to know different preventative measures that they could take in order to reduce livestock predation.
- The Utah Division of Wildlife Resources should know the attitudes of Utahns toward wolves.

Education programs should be a collaborative effort between agencies, nonprofit organizations, and other stakeholders. One of the most important aspects of an education program that is targeted toward a controversial topic is that people agree on the information being taught. An effective education program should consider all sides of the issues involved and include information from the different stakeholders that participate.

Although there are many unique educational needs, there are also educational themes that pertain to many audiences, including:

- **General wolf ecology.** In order to discuss wolf management we believe stakeholders should have fundamental knowledge of wolf foraging habits, social structure, and behavior, as well as their role in Utah's ecosystems.

- **Wolf identification.** Information designed to assist the public in identifying wolves in the wild should be made readily available. Wolves, wolf-dog hybrids, coyotes, and domestic dogs can be similar in appearance; however, they have different levels of legal protection and are managed differently. Although distinguishing wolves from wolf hybrids, and even from some breeds of domestic dogs, is difficult even for experts, we think that an effective education program could at least ensure that people are able to accurately distinguish wolves from coyotes.

- **Wolf management options.** Wolves, like other large carnivores that live in close proximity to humans, are managed. Management actions (e.g., lethal vs. non-lethal control) can be contentious. However, the success of a recolonizing wolf population in Utah may be contingent on certain management actions that are controversial. Therefore, stakeholders should understand all the issues involved with various management options.

- **Perceptions toward wolves.** Many Old World stories and myths have influenced people's perceptions that wolves are a threat to human life. Although there have been occasional wolf attacks on people, the perceived risk is much greater than the actual risk. In fact, there has never been a documented case in North America in which a healthy wolf has killed a human (Carbyn, 1987). An education program should help counter these unfounded myths, while recognizing the potential for dangerous interactions, and providing information on how to minimize the danger.

- **Current legal status.** Currently, wolves in the West are an endangered species and there are a number of legal restrictions that arise from this designation. People should be aware of these restrictions as well as any future changes that may occur.

- **Wolf population size and distribution.** Utahns should be able to access timely and accurate information on wolf population status throughout the state.

- **Ways to reduce potential conflicts with wolves.** Utahns should be able to acquire information on ways to reduce conflicts *(*e.g., livestock, pets, hunting opportunities) with wolves.

- **Opportunities to obtain information.** If Utahns want or need information concerning wolves, it should be available through a variety of sources, including:

    - Pamphlets
    - Regularly issued publications
    - Public meetings
    - Videos
    - Website
    - Traveling display

- Education centers
- Toll free hotline

As not all people get information from the same sources, a variety of techniques for providing information need to be incorporated in a comprehensive education program. Sources listed above should be evaluated to determine their success in delivering information.

The purpose of any Utah wolf education program should not be to persuade Utahns to think one way or another, but rather to increase people's knowledge of wolves and wolf management, as well as to eliminate myths and unfounded fears. In order for a management plan to be effective, education needs to be an integral part of that plan. Thus, education programs must be available, of high quality, and objective for Utahns.

7.2. Public Involvement

Part of the resistance to wolf recolonization in Utah, and in much of the West, is due to a deeply ingrained and long-held distrust of the federal government. To overcome this distrust and maintain support for management programs, an extensive public-involvement system will be required. Perhaps more significant in public involvement than the collection of site-specific data and ideas is the perception of fairness it nurtures. This "procedural justice" greatly enhances acceptance of an outcome, because the participants feel that the process used to reach the conclusion was fair (Lawrence et al., 1997). Prior to any natural recolonization on the part of the wolf, state agencies should conduct an extensive public input solicitation program, and integrate the results into a region-specific planning process. Furthermore, public input should be solicited on a regular, ongoing basis in the future to identify emerging issues and opportunities for conflict resolution once wolves are established.

Utah's existing wildlife management institutions, especially the Wildlife Board and Regional Advisory Councils, remain largely invisible to the general public and are weighted heavily in favor of hunting and agricultural interests (Krannich and Teel, 1999). Whatever mechanism is established to provide public input regarding wolf management, efforts should be made to eliminate real and perceived institutional biases. Given the controversial nature of the wolf debate, we recommend that the Division of Wildlife Resources develop a philosophically and politically balanced Wolf Advisory Committee that would solicit input from scientists, managers, ranchers, hunters, wolf advocates, and other interested parties. Although wolf management involves economics, politics, and sociological issues, its core must be based on biology. Therefore, we recommend that the committee include an adequate number of wildlife biologists as members (at least 25%). The primary functions of the Wolf Advisory Committee should be to develop both short and long-term management objectives and goals to be considered by the Division of Wildlife Resources, the Regional Advisory Councils, and the Wildlife Board.

For the Wolf Advisory Committee to be successful, it should be independent, have a clearly articulated mission, and sufficient support from the Division of Wildlife

Resources. In terms of soliciting public input, we further recommend the following guidelines:

- **Clearly defined scope.** The purpose of this process should not be to debate whether wolves should be in Utah, but rather to determine how best to manage wolves for the citizens of Utah. Although various stakeholders may hold differing opinions on whether the presence of wolves in Utah is desirable, our recommendations are targeted at the development of a management plan.

- **Early and often.** A major complaint regarding the public participation policies of government agencies is that the public is invited after the decision has, in reality if not officially, already been made. Since wolf recolonization is imminent, it is imperative that this process begins now to guarantee that public input is included in all stages of the development of any management plan.

- **Multiple methods.** A passive, open-door approach to public participation may result in a self-selecting process that tends to skew the input toward those having the time, strong interest, and ability to respond (Decker and Chase, 1997). To reach the greatest possible cross-section of interests, and to avoid possible response biases associated with a particular format (e.g., open houses, surveys), a combination of methods should be used.

- **Addressing issues.** A legitimate public participation process requires that a sincere effort be made to address all of the issues raised.

8. Tribal Involvement

There is precedent for tribal cooperation in wolf recovery. For example, when the state of Idaho refused to participate in wolf reintroduction, the Nez Percé Tribe took responsibility (Nijhuis, 2001). The tribe manages wolves throughout the Central Idaho Recovery Area, although the Nez Percé Reservation includes only about 304 square km. Although we do not foresee a similar situation developing in Utah, the cooperation of Native Americans living and working in and around potential wolf habitat would seem essential. In particular, the Uintah and Ouray Reservation, managed by the Ute Tribe, includes a substantial portion of the largest contiguous area of high-quality wolf habitat in Utah (see Section 4.2). The Ute Tribe, at present, does not support wolf reintroduction (K. Corts, Ute Indian Tribe Fish and Wildlife Department, personnal communication), although their position on natural recolonization is unclear.

A primary concern of the tribe is the potential for land-use restrictions as a result of critical habitat designation under the Endangered Species Act. We believe that significant restrictions are unlikely to occur under federal or state management. Little critical habitat was designated under the Northern Rockies Recovery Plan (E. Bangs, USFWS, personal communication), and no additional habitat is likely to be designated now, given that wolf populations are increasing without it. Similarly, no such designations have been implemented in Minnesota, Wisconsin, or Michigan. Furthermore, if a nonessential/experimental population is established, it is certain that no critical habitat would be designated (16 U.S.C.A. 1536 § 10(j)(2)(C)(ii)). It is possible, however, that temporary land use restrictions might be imposed near denning sites, depending on the specifics of the management plan.

A second concern is the potential impact on game permit sales, which currently generate $300,000-$400,000 annually from nonmembers. A related concern is the potential impact on Tribal members who hunt for subsistence. However, we believe these impacts would likely be minimal, based on our biological and economic analysis (see Sections 4.4.1 and 5.2.5). In any case, it will be important to monitor the effects of wolves on game populations in the area. Currently, there is limited cattle grazing on the northern part of the reservation, and there is some concern regarding the potential impact of wolves on that operation. Whatever the potential impacts may be, encouraging the participation of not only the Ute Tribe, but also Utah's other tribes, should be an integral part of the planning process. We suggest that a strongly participatory approach to the Ute Tribe would maximize the chances for successful collaboration. The presence of tribal members on the Wolf Advisory Committee will not only facilitate this process, but also help defuse any potential conflicts and misunderstandings.

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