EFFECTS OF WINTER RECREATION ON WILDLIFE OF THE GREATER YELLOWSTONE AREA: A LITERATURE REVIEW AND ASSESSMENT

Greater Yellowstone Winter Wildlife Working Group
Greater Yellowstone Coordinating Committee

October 1999

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PREFACE

This publication is a cooperative project of the Greater Yellowstone Coordinating Committee (GYCC) and was undertaken at the request of the Greater Yellowstone Winter Visitor Use Management Working Group (Working Group). Because the Working Group felt that the effects of winter recreation on wildlife had not been adequately addressed, the Winter Wildlife Working Group (Wildlife Group) was formed in December 1996. Twenty-six biologists and resource managers from the Forest Service, National Park Service, the states of Montana, Idaho, and Wyoming, and private organizations were invited to participate; 18 submitted papers.

The Wildlife Group first met in December 1996. We commissioned Jim Caslick, Ph.D. (Caslick 1997), retired wildlife biology faculty of Cornell University, to update an annotated bibliography on the effects of winter recreation on wildlife commissioned by Grand Teton National Park in 1995 (Bennett 1995). We examined these bibliographies, an additional bibliography supplied by the Biodiversity Legal Foundation (1996), and independent sources to address impacts to wildlife species and issues of concern.

This document is only the first step in addressing the effects of winter recreation on wildlife. The short time frame allotted for developing the issue statements did not allow for original research, though clearly more research is needed on this important topic. New information is also coming to light concerning the effects of two-cycle engines on air and water quality and the deposition of heavy metals in the snowpack. This new information is not included in this document. Additionally, there is no cumulative impacts analysis in this document, as that was beyond the scope of this effort.

We hope that this document will be useful to managers, biologists, and scientists as they manage and further explore the effects of winter recreation on the environment.

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Biodiversity Legal Foundation. 1996. Report and formal comments on the current and potential adverse impacts of winter recreational use in Yellowstone National Park and the winter use management planning process by the U.S. National Park Service. Boulder, Colorado, USA.

Caslick, J. W. 1997. Impacts of winter recreation on wildlife in Yellowstone National Park: a literature review and recommendations. Report to the National Park Service, Yellowstone National Park, Wyoming, USA. Appendix I, this document.

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The project is the result of many hours of hard work by federal, state, and private biologists from throughout the Greater Yellowstone Area. Contributors took time from their busy schedules to research, write, and review the individual chapters, often volunteering their time and expertise. We are grateful for their effort and dedication.

Tom Olliff, Kristin Legg, and Beth Kaeding edited this report. Christy Hendrix and Tami Blackford assisted with technical editing. In addition, Tami completed document layout.

Finally, this project would not have been possible without the financial and moral support of John Sacklin, Chief, Planning and Compliance, Yellowstone National Park.

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INTRODUCTION

Since the first snowmobiles entered Yellowstone National Park in 1963, the number and types of winter recreationists have steadily increased. While media attention has focused on Yellowstone National Park, winter recreation on public lands throughout the Greater Yellowstone Area (GYA) has increased as well, for example snowmobilers in the Lionshead/Two-Top, Island Park, and Cooke City areas; skiers around Cooke City and Teton Pass; and snowshoers, dog sledders, and resort skiers throughout the ecosystem. Many of these activities have experienced explosive growth in the last decade.

In 1990, Yellowstone and Grand Teton national parks issued the *Winter Use Plan* for the two parks following public involvement and an environmental assessment. At the time, winter visitation in the parks was about 123,000 visitors. The plan forecast that winter use of the parks would not increase quickly and would not reach 140,000 (the high projection) for 10 years. However, that use level was reached by the 1992–93 winter, and, as directed by the plan, the parks began to address use levels by developing a process to assess visitor use.

Because winter use of the parks is only a portion of the winter use that occurs in the GYA, the other members of the Greater Yellowstone Coordinating Committee (GYCC) shared many of the same concerns of park managers. In April 1994, the GYCC chartered a team made up of staff from Yellowstone and Grand Teton national parks and Gallatin, Targhee, Shoshone, Bridger–Teton, Custer, and Beaverhead–Deerlodge national forests to study winter visitor use issues and to develop an assessment of use. This assessment, titled *Winter Visitor Use: A Multi-Agency Assessment*, showed that human use is not only increasing, but it is also expanding into areas that received little or no use in the past. Groomed snowmobile trails as well as some cross-country ski trails, particularly on national forest lands, are being expanded to accommodate this increase.

In 1995 the national parks conducted a scientifically based survey of its visitors. While many activities were listed as important, 93 percent of visitors to Yellowstone and 89 percent of visitors to Grand Teton rated wildlife as “very important” or “extremely important.”

Land managers, area residents, and the visiting public are concerned about the effect that the current levels of winter recreation may be having on the natural environment and wildlife. Human activities continue to expand into wildlife habitats. To minimize the impacts of these activities, wildlife managers need to be aware of the effects of these activities and to understand how to mitigate for them.

While much of the information in this document will be useful in areas beyond the GYA, the document does focus on many issues specific to this area. For example, one task accomplished through the visitor use management process was to describe the entire Greater Yellowstone Area in terms of Potential Opportunity Areas (POAs). Potential Opportunity Areas describe an area’s recreation potential, not necessarily its existing condition. The experiences range from those that are easily accessible and highly developed to those that are considered remote backcountry experiences. Complete descriptions of POAs can be found in Appendix II. How wildlife could be affected in various POAs is described in this review.

The purpose of this document is to provide guidelines for managing winter recreational use in the context of preserving wildlife populations. Several topics are discussed, including the current population status and trend of the individual species, relevant life history data, information on winter habitat use, summaries of studies on the influence of human activities on individual species in the winter, and the potential effects of specific winter recreational uses on those species. Papers that were peer-reviewed prior to the compilation of these papers are noted as such. All papers were subject to a joint review process by biologists and managers before being submitted to the final editing process.

MAMMALS

Photo courtesy of the National Park Service

EFFECTS OF WINTER RECREATION ON BIGHORN SHEEP

POPULATION STATUS AND TREND

Bighorn sheep (*Ovis canadensis*) were historically found throughout the mountains of western North America. Prior to the arrival of European man, their population is estimated to have been between 1.5 and 2 million. Bighorn sheep numbered fewer than 42,000 in 1974 (Wisthart 1978 in Reisenhoover et al. 1988). This decline was caused by competition with livestock, introduction of diseases, hunting, and loss of habitat during European settlement of the West (Buechner 1960, Keating 1982). With the establishment of management areas and hunting regulations, bighorn sheep have reoccupied some of their historic ranges, although populations have not reached pre-settlement sizes.

The creation of Yellowstone National Park in 1872 provided needed protection for the Rocky Mountain bighorn. In the early 1900s, fewer than 150 bighorn sheep were thought to exist in Yellowstone, and by 1912 managers estimated that 200 bighorns were in the park (Seton 1913, Mills 1937). Presently, bighorn sheep are found in limited areas of suitable habitat throughout the Greater Yellowstone Area (GYA); estimates of their numbers are included in Table 1. Larger populations are found along the eastern boundary of Yellowstone, with some populations having more than 1,000 animals.

Table 1. Estimated bighorn sheep population sizes in the Greater Yellowstone Area

Location	Estimated Number
Yellowstone National Park	240–325
Gallatin Mountains	50–65
Upper Yellowstone River, North of Yellowstone	60–75
Absaroka Mountains, Montana	130–175
Absaroka Mountains, Wyoming	4,190
Grand Teton Mountains	100–150
Madison Range	40–50
Gros Ventre Range	550
Wind River Mountains	900
Wyoming Range	75–100
Estimated Total	6,335–6,580

Today, bighorn populations continue to have some of the same problems that bighorns had when European settlers first arrived. In the winter of 1981–82, a chlamydia (a contagious infection of the eye) outbreak on the Mt. Everts winter range in Yellowstone reduced the bighorn population by more than 50 percent, from 487 to 159 (Meagher et al. 1992, Caslick 1993). Since that time the bighorn population has increased only slightly, and in 1996, 167 bighorns were observed on the same winter range surveyed before the outbreak (Lemke 1996).

Other populations in the GYA have declined as well (Jones 1994; Legg 1996; L. Irby, Montana State University, personal communication; S. Stewart, Montana Fish, Wildlife and Parks, personal communication; L. Roop, Wyoming Game and Fish Department, personal communication). The most recent decline was noted in the Madison Range population near Quake Lake, Montana, during the winter of 1996–97. It is believed that disease, predation, and human impacts such as illegal hunting, loss of habitat, and winter recreational use of winter ranges have contributed to these declines.

The loss of habitat and the fact that bighorns use traditional migration routes are the primary problems facing bighorn sheep today and are often mentioned as concerns for bighorn sheep management (Constan 1975; Horejsi 1976; Martin 1985; Reisenhoover et al. 1988; Environmental Protection, Fish and Wildlife Service 1993).

LIFE HISTORY

Adult ewes become mature at 2½ years. The breeding season occurs from November through late December, typically on winter range. Lambing occurs from mid-May through June, either near the winter range or during spring migration (May through July), and often along steep, precipitous cliffs. Fall migration is from October through December. The timing of both migrations depends upon weather and snow levels. Bighorn sheep typically remain in separate ewe/lamb and ram groups except during the rut. Males leave ewe/lamb groups between age 2–3.

HABITAT

Bighorn sheep utilize different ranges in the winter and summer, and they have an established migration route between these areas. The knowledge of these traditional ranges and migration routes is passed down from one generation to the next. By a bighorn's fourth year, it has learned its band's traditional home ranges and migration patterns (Geist 1971, Reisenhoover et al. 1988) and will use them the rest of its life. Any alteration of these habitats or routes could be detrimental for a population of bighorn sheep.

The amount of available winter range for Rocky Mountain bighorn sheep is usually more limited than the amount of summer range because of snow depth and spatial distribution. Because of this, winter range can be the critical habitat factor in the survival of bighorn sheep. Bighorns typically use lower elevation ranges in the winter because of low snow coverage in these areas, although some winter at higher elevations on windswept south-southwest facing slopes, usually above the thermocline (Oldemeyer et al. 1971). These higher elevation winter ranges can be problematic because bighorns have limited access to forage. The greater snow depths surrounding the small, available areas of forage habitat make movement from patch to patch difficult.

Habitat features that are important for bighorn sheep survival include the distance to escape terrain, slope, salt availability, elevation, aspect, forest cover, shrub availability, biomass and nitrogen content of palatable grasses, and snow depth/snow pack.

HUMAN ACTIVITIES

Protecting critical winter range by limiting human impacts is important for maintaining bighorn sheep in the GYA. Winter recreational use near or on bighorn sheep winter ranges may affect bighorns during the rut, during winter on the winter ranges that have limited amounts of available habitat, or in the spring during the lambing season.

The following types of recreational use could potentially affect bighorn sheep: hikers, wildlife photographers/observers, ice climbers, hunters, snowshoers, skiers, snowmobilers, sled dogs, and dogs on or off leashes. On ranges where bighorns are hunted, they are more sensitive to the presence of humans (Horejsi 1976). Any human activity on bighorn sheep winter range, especially within 100 yards of escape terrain, could affect bighorn sheep survivability.

Recreational activities may cause stress in bighorn sheep leading to increased heart rate and energy expenditures (MacArthur et al. 1982) and/or cause displacement from preferred foraging areas to less optimal habitat (Horejsi 1976, Hicks and Elder 1979). Bighorns typically forage during the warmest part of the day to minimize energy loss. If bighorns alter their foraging activities either spatially or temporally, they increase their exposure to predators, decrease the quality and quantity of food available to them, and increase their energy loss. Any decrease in energy intake or increase in energy expenditure as a result of human recreational activity may lead to the death of an already winter-stressed animal either directly by starvation or indirectly by lowering resistance to diseases or predation. The effects of human recreation can be considered an additive factor in lowering survivability in bighorns (Horejsi 1976).

MacArthur et al. (1982) showed elevated heart rates and fleeing behavior in bighorn sheep when approached by humans. This behavior was very apparent when humans surprised the bighorns or at any time dogs were present. The heart rate of the bighorns did not decrease with successive approaches, although if a predictable human behavior occurred (*i.e.*, direction and timing of approach), the bighorns became habituated and little response would be noticed except when a dog was present. If bighorns had been harassed earlier by a predator or human then the current harassment caused a greater response than normal.

In Montana, snowmobiles may have contributed to a decline in a bighorn sheep population in the Rock Creek drainage. The stress from the snowmobilers added to the natural stresses incurred during the winter (Berwick 1968). Human disturbance was also found to be a limiting factor for a population of bighorns in the Sierra Nevada Range. Herd size, human distance to the bighorns, and the elevational relationship of humans to bighorns were important factors in determining the reaction of bighorn sheep when approached by humans (Hicks and Elder 1979).

Boyle and Samson (1985) noted that rock climbing on or near bighorn sheep escape terrain can affect bighorns. Horejsi (1976) believes that improved access and more leisure time has increased recreational activities (from snowmobiling to walking the dog), which has resulted in more harm to wild bighorns. Because humans behave differently than natural predators (they often persist in following the bighorns to their escape terrain), they can displace bighorns from traditional areas.

There is the possibility that bighorn sheep may sometimes congregate near humans as a protection from predators, although the harassment by humans has to be less than the chance of predation. Along the Gallatin Ridge trail, there are two bighorn sheep summer ranges in the Hyalite and Tom Miner basins. There are many areas of bighorn habitat along the 30-mile-long ridge, but bighorn sheep were observed at locations having high visitor use relative to the rest of the area (Legg 1996). In winter, bighorns may not use the human/predator relationship to select habitat, as winter habitats are already limited to a few select areas.

POTENTIAL EFFECTS

Recreationists may cause increased stress for bighorn sheep during critical winter months, which may influence their survivability. Human use on the winter range during the breeding season could interfere with breeding by adding more stress to the rams and ewes. This may decrease the overall productivity of the population and increase the probability of predation and death.

Bighorns may abandon high quality winter range that is used heavily by humans, or they may limit their use to a small area near escape terrain. These limitations will decrease the available habitat used by bighorns or push them into areas with a greater potential for predation. If bighorns are unable to forage during the day because of recreationists, they will use more energy to forage when it is colder. Development on winter ranges or along migration corridors will decrease the already limited habitat available for bighorns.

During the lambing season ewes could be pushed into less optimal habitat, exposing the lambs to predators and environments with harsher weather.

Bighorn sheep in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(2) Primary transportation routes
(3) Scenic driving routes
(6) Backcountry motorized areas
(9) Backcountry nonmotorized areas
(10) Downhill sliding (nonmotorized)
(12) Low-snow recreation areas

MANAGEMENT GUIDELINES

- Human approach to the critical areas of bighorn habitat should be limited. A buffer zone should be established around bighorn sheep escape terrain.
- Human activities should be limited to roads or trails to minimize disturbance to bighorn sheep (MacArthur et al. 1982).
- Dogs should be prohibited on any bighorn sheep winter range (MacArthur et al. 1982).
- The remaining bighorn sheep habitat should be protected to ensure that migration corridors will remain intact and that traditional ranges are maintained.
- Special protection measures should be enforced during brief critical periods such as breeding, lambing, and severe winter weather (Boyle and Samson 1985).
- Activities such as ice climbing, wildlife photography/observation, and hiking that occur on lower elevation winter ranges should be monitored very closely. If there is any indication that bighorn sheep are being displaced either spatially or temporally, the activities should be stopped or managed to protect the bighorns.
- Skiing, snowmobiling, mountaineering, and snowshoeing will most likely only affect bighorn sheep wintering at higher elevations. The encounters between these recreationists and the bighorns may be infrequent enough that there would be little or no impact to the animals. However, if use increases at these higher elevation winter ranges, managers need to monitor the situation in order to prevent the loss of bighorn sheep on isolated winter ranges.

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EFFECTS OF WINTER RECREATION ON BISON

POPULATION STATUS AND TREND

Bison (*Bison bison*) once roamed most of central North America and are native to the Greater Yellowstone Area (GYA). In the 1870s and 1880s, bison were nearly eliminated by market hunting; only a few small isolated populations remained. In Yellowstone National Park, poaching further reduced bison numbers, and, in 1902, 23 bison were counted in the Pelican Valley area of the park. To preserve the species, park managers imported 21 bison from captive herds in Montana and Texas and intensively managed the animals at the "Buffalo Ranch" in the Lamar Valley using livestock techniques. By the winter of 1926–27, the bison population had grown to more than 1,000 (Meagher 1973).

The ranching operation ended in the mid-1930s, when National Park Service (NPS) policy shifted from simple preservation to conservation of species in more natural conditions. The captive herd then intermingled with the remaining wild bison herd that survived in Pelican Valley. From the late 1930s through 1967, NPS managers utilized herd reductions to achieve range management goals. In 1967, when manipulative management of wildlife populations ceased, 397 bison were counted in the entire park. Bison numbers were then allowed to fluctuate in response to environmental factors. Since 1967, the bison population increased to a peak of 3,956 in the winter of 1994–95 and then declined to 3,398 in the winter of 1995–96.

In 1968, in response to livestock industry concerns about the disease brucellosis, the NPS proposed a program to control bison at the boundary of the park. Hazing, herding, baiting, physical barriers, and scare devices were used to discourage bison from leaving the park, generally with little success (Meagher 1989). Shooting bison was used as a last resort. From 1968–84, only a small number of bull bison were removed as they attempted to move beyond the park boundary. Beginning in 1985, the state of Montana used hunting to control bison moving from the park into Montana. In the severe winter of 1988–89, following summer drought and area fires, hunters in the state of Montana shot 569 bison as they left the northern portion of the park. Bison continued to leave the park each winter in varying numbers, and, in the extremely severe winter of 1996–97, Montana state officials and park rangers shot or captured and sent to slaughter 1,084 bison. This, added to estimates of 300–400 dying from such natural causes as extreme weather, winter kill, and starvation, brought the total bison population in Yellowstone down to an estimated 2,000 animals in spring 1997 (NPS 1998). After reproduction, the early winter population count was 2,105 bison for the winter of 1997–98.

LIFE HISTORY

Bison are highly social animals. Females and subadults wander together in large herds with bulls, singly or in small bands, on the periphery of the group. The rut occurs in late summer (July and early August), and calves are born in April and May. At a few hours of age, a calf can keep up with its mother (Meagher 1973).

A large bison bull may stand six feet at the shoulder and weigh 2,000 pounds. Female bison are similar in appearance to males, although they are smaller and have more slender horns that point forward. Bison have a heavily muscled neck that supports a massive head, which is swung back and forth in winter to move snow from forage.

HABITAT

Bison are grazers and consume large amounts of sedges and grasses. Bison do use forested areas. In winter bison are typically found in open meadows and thermally influenced areas. Yellowstone's bison winter in three fairly distinct areas with some overlap of animals between the wintering areas at various times during the year. These wintering areas are called the Northern (Lamar Valley), the Mary Mountain (Hayden Valley–Firehole River), and the Pelican Valley.

HUMAN ACTIVITIES

Winter recreational use can have several impacts on wildlife. These include harvest of animals (via trapping, hunting, poaching), habitat modification, pollution, and disturbance. These impacts can have a number of effects on wildlife species, including behavioral change or death. Behavioral change may consist of altered behavior, altered vigor, or altered productivity. The abundance, distribution, and demographics of populations can be affected, and this can result in changes in species composition and interactions among species (Knight and Cole 1995). Alteration of wildlife movements or displacement from normal wintering areas can result in higher energetic costs for winter-stressed wildlife, potentially decreasing production of young. Occasionally, direct mortality may occur as in the case of snowmobile–wildlife collisions.

There have been various studies related to winter recreation and its impact on wildlife as evidenced by recent literature reviews by Caslick and Caslick (1997) and Bennett (1995). However, there are few completed studies that specifically focus on the effects of winter recreation on bison.

POTENTIAL EFFECTS

MOVEMENTS

Bison establish a network of trails and travel routes in the winter as the snow depth and crust become severe. Bison often use rivers, streams, and marshes for travel as well as packed and groomed snowmobile trails (Aune 1981, Bjornlie and Garrott 1998). Groomed trails may be used extensively by bison; snow-packed roads used for winter recreation in Yellowstone National Park may be a major factor relating to the expanded distribution of bison in the park (Meagher 1993). According to Aune (1981), bison utilized groomed snowmobile trails regularly to travel from place to place. Bison were not observed using ski trails. Bjornlie and Garrott (1998) and Kurz (1998) also found that bison use the groomed roads as part of their network of trails; however, the majority of bison movements took place off of established roads and trails.

DISPLACEMENT

The most dramatic physiological defense response is observed when wildlife are provoked by humans on foot (Gabrielsen and Smith 1995, Cassirer 1990). The magnitude of the response depends on the distance, the movement pattern of the person(s), and the animal's access to cover. Animals will respond in a passive or active manner, depending on species and the particular situation.

In their initial response to human disturbance, bison usually "freeze" body movements, and there may be increased interaction among the bison group (Aune 1981). However, bison will also flee in response to disturbance; they usually flee by galloping or trotting away from the source of the disturbance (Aune 1981). The visual stimulus of a snowmobile or skier seems to initiate the flight response. Except for coyotes, Aune (1981) and Cassirer (1990) found that all wildlife species observed (mostly big game) reacted more quickly to an approaching skier than to a snowmobile, and the flight distance was generally greater from skiers. Bison were found to respond dramatically to skiers who were off established trails. All wildlife species studied, including bison, were wary of people on foot.

Most snowmobile–wildlife encounters occurred either early in the day (between 8 and 10 a.m.) or late in the day (between 5 and 6 p.m.). Most snowmobile–bison interaction occurred because of the bison's presence on groomed trails, and the number of interactions increased with snow depth (Aune 1981). Many bison flee when they encounter snowmobiles because they are "herded" down the trail by snowmobilers. Heavy human activity may temporarily displace wildlife from areas within 63 yards of the trail (Aune 1981). Heavy human activity sometimes occurs in areas that are winter range for big game such as bison. Snowmobile use is often more predictable and localized than skier activity and may cause less displacement of animals. Varied topography and good cover may reduce the frequency and intensity of displacement. Even a natural barrier, such as a river, may result in higher tolerance of snowmobile activity.

ENERGY EXPENDITURE

Winter recreational activity may significantly increase wildlife's expenditure of fat reserves. At the time of Aune's (1981) study, wildlife species in this area were dramatically increasing in population size, so the impact of winter recreational activity was apparently not influencing reproductive success. In some situations, wildlife may become habituated to human disturbance and the physiological responses decrease (Gabrielsen and Smith 1995). Wildlife, including bison, that are habituated gradually during the first two weeks of human disturbance (Aune 1981) may expend less energy when disturbed after that time.

Bison may use groomed snowmobile trails, packed trails, and plowed roads for travel through areas where surrounding snow is deep. However, bison may not use these trails if the packed routes are not within foraging areas or do not lead to them (Bjornlie and Garrott 1998). These types of routes facilitate bison movement by making movement more energy efficient. Bison may no longer be "snowbound" in locations where they have had to spend the winter in the past. Increasing numbers of bison have adapted to snow-packed roads and are using them as a travel route to access forage sites (Meagher 1993). Despite the presence of snow-packed roads, bison continue to use natural corridors, such as riverbanks where snow depth is ameliorated (as along the Madison) or the riverbed itself, to reduce energy expenditures.

Bison in the GYA are particularly affected by human use of the following Potential Opportunity Areas (POA):

(4) Groomed motorized routes
(5) Motorized routes

Bison may also be an issue in POA (3) scenic driving routes. This depends on the effect that plowed roads have on bison movement, and how long this has been occurring. The road to Cooke City from Mammoth has been plowed since the 1940s. This road traverses the northern winter range. This area is considered big game winter range due to lesser snow depths in winter. Bison are known to travel on the plowed road, but it is unknown if the road facilitates travel to winter ranges that were not used by bison in the past or allows them to exit from areas where the snow becomes too deep.

There may be some concern in areas where cross-country skiing occurs, primarily POA (9) backcountry nonmotorized areas, because of the potential for stressing bison in the winter and causing energy loss.

CONTINUING RESEARCH

There are several bison research projects ongoing in the GYA, including:

1. Determining forage availability and habitat use patterns for bison in the Hayden Valley of Yellowstone National Park.
2. Seasonal movements and habitat selection by bison in Yellowstone National Park.
3. Development of aerial survey methodology for bison population estimation in Yellowstone National Park.
4. Spatial-dynamic modeling of bison carrying capacity in the greater Yellowstone Ecosystem—A synthesis of bison movements, populations dynamics, and interactions with vegetation.
5. Population characteristics of Yellowstone National Park bison.
6. Bison interactions with elk and predictive models of bison and elk carrying capacity, snow models, and population management scenarios in the Jackson Valley.
7. Bison use of groomed roads in the Hayden Valley and Gibbon Canyon to Golden Gate areas of Yellowstone National Park.
8. Statistical analysis and synthesis of 30 years of bison data.
9. The effects of groomed roads on the behavior and distribution of bison in Yellowstone National Park.
10. Assessing impacts of winter recreation on wildlife in Yellowstone National Park.

MANAGEMENT GUIDELINES

- Where possible, consider rerouting snowmobile trails so that they are located outside of critical bison winter ranges and bison concentration areas.
- Where major bison migration routes intersect groomed snowmobile trails or snowmobile-use routes, consider relocating snowmobile trails or user routes.
- If bison are traveling plowed highways that have berms, plow frequent “pull-outs” where bison can escape from vehicular traffic.
- Increase interpretive contacts with snowmobilers, skiers, and snowshoers to educate these winter recreational users about off-trail use and wildlife responses.
- Consider restricting human use in areas of critical wildlife winter range.
- Continue to study the influence of packed trails on bison movement and distribution. Determine if this influence is acceptable where it varies from historical versus critical winter use.

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EFFECTS OF WINTER RECREATION ON ELK

POPULATION STATUS AND TREND

By the early 1900s, elk (*Cervus elaphus*) populations throughout North America had been decimated by commercial exploitation, competition with domestic livestock, and habitat changes. Most of the estimated 50,000 remaining elk were concentrated in the Yellowstone National Park (YNP) and Jackson Hole areas (Seton 1927). Protection of wildlife in YNP through installation into Yellowstone of the U.S. Army in 1886 and passage of the Yellowstone Park Protection Act in 1894 helped to reduce illegal killing in the park, and by the early 1900s the park's elk population began to stabilize or increase in number (Houston 1982, Robbins et al. 1982). Conflicts with livestock operations, combined with a series of severe winters that resulted in heavy losses of elk, caused continued concern about the future of the elk population that wintered in the Jackson Hole area (Robbins et al. 1982). In response to these concerns, Congress in 1912 passed legislation authorizing creation of the National Elk Refuge (NER) in Jackson Hole. Since the early 1900s, when management efforts were directed primarily at preserving and enhancing elk populations in the Greater Yellowstone Area (GYA), the management of elk populations has undergone several phases. In YNP, predator control, winter feeding, and effective protection from poaching resulted in a stable or increasing elk population (Houston 1982), which, in turn, created concerns about habitat degradation. Beginning in the 1930s and continuing until 1969, an average of 327 elk per year were removed from the park (Houston 1982), mainly from the northern range, through trapping for translocation and shooting. In 1969, the park placed a moratorium on elk removals (Cole 1969). That period marked the beginning of a management philosophy that continues to the present, in which the park has attempted to allow natural processes, to the maximum extent possible, to regulate ungulate numbers within Yellowstone. After the NER was established in Jackson Hole, the elk population there began to stabilize, although the number of elk in the adjoining Grand Teton National Park (GTNP) continued to decline until mid-century (Smith and Robbins 1994). Managers have been concerned about the large numbers of elk wintering on a restricted area in the NER and the impacts that they may have on forage supply and habitat quality. Therefore, an elk hunt was established on the refuge and in a portion of the adjoining GTNP (Smith and Robbins 1994). The states of Montana, Idaho, and Wyoming manage elk herds in the GYA by monitoring herd numbers and often herd composition, setting population and habitat objectives, and conducting regulated hunts. All of the elk herds in the GYA are subject to hunting in at least a portion of their ranges. Some elk that summer in YNP, which is closed to hunting, may be hunted as they migrate south to winter range (Smith and Robbins 1994). Most of the elk herds in the GYA were either stable or increasing during the 1980s (USFWS 1994), although a few have experienced declines in recent years. Populations south of YNP have been at or above stated population objectives in recent years.

Currently, an estimated 50,000–60,000 elk inhabit the GYA, in 10–12 separate herds (USFWS 1994). The northern Yellowstone elk herd summers in the northern and eastern portions of YNP and surrounding mountains, and as far south as Yellowstone Lake (Houston 1982). This herd's winter range extends from the Lamar Valley in the northeastern corner of YNP, north and west to the Dome Mountain

Wildlife Management Area outside YNP (USFWS 1994). This herd numbered around 20,000 in the early 1990s (USFWS 1994), but counts in 1998 and 1999 indicate that the northern herd currently numbers around 12,000 animals (Montana Fish, Wildlife and Parks, unpublished data; National Park Service, unpublished data).

A migratory herd of approximately 3,000–4,000 elk summers in the northern mountains of YNP and moves into the southern portion of the Emigrant elk management unit north of YNP during winter (MFWP 1992). This herd, which has been increasing in recent years, joins a resident herd of approximately 800–1,000 elk that summers in the Absaroka Mountains north of Yellowstone and winters in the foothills east of the Yellowstone River, north of YNP (MFWP 1992).

Three herds inhabit the area to the west and northwest of YNP. The Madison–Firehole herd resides year-round in the Madison and Firehole river drainages within and adjacent to the western boundary of YNP. Numbering approximately 600–800 animals (USFWS 1994), this herd is generally non-migratory (Craighead et al. 1973). Geothermal sites and thermally influenced areas are critical to the overwinter survival of this herd, which winters in a harsh area where snow depths peak at 115–150 cm annually (Craighead et al. 1973, Pils 1998). The availability of thermally influenced areas with associated reduced snowdepths may provide an upper limit to the size of this herd (Craighead et al. 1973). Another population of elk summers in the Gallatin and Madison ranges within YNP and west of the YNP western boundary and winters east of the Madison River in the foothills of the Madison Range (USFWS 1994). This population is believed to be increasing and was estimated at nearly 7,000 in 1992 (MFWP 1992). The Gallatin herd summers primarily in the northwest corner of YNP and winters along the Gallatin River in the Gallatin Canyon area in Montana (USFWS 1994). This herd numbers approximately 1,200–1,400 animals (MFWP 1992). Wildlife managers are concerned about increasing development on this herd's winter range in addition to a lack of security cover (MFWP 1992). A sub-population of the Gallatin herd summers at high elevations along the Gallatin Mountain Range and in the northwest corner of YNP (USFWS 1994). This group winters in the mountainous areas west of the Yellowstone River and northwest of the YNP boundary. The total Gallatin area elk population was estimated at about 2,900 during the early 1980s (USFWS 1994), and had increased to approximately 3,600–3,800 by 1992 (MFWP 1992).

Three elk herds along the eastern boundary of YNP summer primarily in the park. The Clark's Fork herd winters along the Clark's Fork River northwest of Cody, Wyoming, and numbered approximately 3,600 animals in 1988 (USFWS 1994). The North Fork Shoshone herd winters along the North Fork Shoshone River drainage west of Cody, Wyoming. This herd was estimated at roughly 2,900 elk in the late 1980s (USFWS 1994). The Carter Mountain herd winters in the Carter Mountain area and along the South Fork Shoshone River southwest of Cody, Wyoming, and consists of approximately 3,100 elk (USFWS 1994).

To the south and southwest of YNP and GTNP are three elk herds that spend all or part of the year in the GYA. Elk from the Targhee herd south of YNP summer generally outside YNP and winter along the Idaho–Wyoming border south of YNP (Mack et al. 1990). Approximately 500 elk were counted in the Targhee herd in the late 1980s (USFWS 1994). The Jackson herd, which winters on the NER and in the Gros Ventre River Valley, summers in the mountains to the north and east, including areas in Yellowstone and Grand Teton national parks and portions of the Bridger–Teton National Forest (Mack et al. 1990, Smith and Robbins 1994). From 1978 to 1982, roughly 7,600 elk wintered on the NER annually (Smith and Robbins 1994). The entire Jackson elk herd was estimated at approximately 16,000 animals in 1988 (USFWS 1994). The Sand Creek elk herd in eastern Idaho, which numbered approximately 4,200–4,900 in the mid- to late 1980s, summers east of Highway 20 in or near YNP, and winters in the Sand Creek winter range southeast of Dubois, Idaho (Brown 1985).

LIFE HISTORY

Elk are gregarious animals, and for most of the year males and females remain grouped in separate herds. Females begin to restrict their range and gather in traditional rutting areas in August and September (Martinka 1969), where, by early October, they are joined by males (Nowak 1999). During October males compete for females and attempt to gain and hold a harem of females through displays involving high-pitched bugles, antler thrashing, urine spraying, and fighting (Murie 1951, Geist 1982, Nowak 1999). Males may incur serious injury during the rut, which is usually done by late October. Many elk populations in the western U.S. migrate to low elevation winter range (Nowak 1999), where they may aggregate in groups of up to several thousand animals (Boyd 1978). The gestation period is roughly 250–265 days (Clutton-Brock et al. 1982, Taber et al. 1982), after which usually a single calf is born, generally in late May or early June (Murie 1951, Peek 1982). Sex ratio at birth is usually 1:1 (Peek 1982). Females may separate themselves from the larger herd to give birth in isolated areas, where they remain with their calves for several weeks (Boyd 1978). Lactation may last 4–7 or more months (Nowak 1999). Females generally attain sexual maturity at about 2½ years of age, and then are capable of producing a calf annually (Nowak 1999). Males are capable of mating at the same age, but most do not successfully breed until much later because of competition from older bulls (Nowak 1999). In wild populations few elk live longer than 12–15 years, with males often living shorter lives than females because of injuries incurred during the rut and decreased ability to deal with poor forage condition during the winter when they are nutritionally stressed from the rut (Peek 1982, Nowak 1999). In heavily hunted populations, the ratio of adult bulls to adult cows may be quite low (Peek 1982). The major source of mortality in most elk populations, including those in the GYA, is hunter harvest and associated crippling loss and illegal kills (Peek 1982). Wolves, cougars, and occasionally coyotes and domestic dogs may prey on both adult and calf elk (Murie 1951, Hornocker 1970, Carbyn 1983, Murphy et al. 1992, Gese and Grothe 1995). Both black and grizzly bears may be an important predator on elk calves in some areas (Murie 1951, Singer et al. 1997). Other sources of mortality are drowning, miring in thermal mud, fighting during the rut, entanglement in fences, and starvation (winterkill) (Murie 1951). Vehicle collisions also contribute to elk mortality in most GYA herds.

HABITAT

Skovlin (1982) described the basic requirements of elk habitat. Habitat selection is determined by topography, weather, vegetational cover, and escape cover. Elevation is probably the most important topographic influence, determining seasonal availability of habitats. The most important influences of weather on elk habitat use are snow depth and condition, which limit elk movement and forage availability. Vegetative characteristics that are important determinants of elk habitat use include cover for both thermoregulation and hiding or escape, as well as forage availability. Elk are an ecotone species (Skovlin 1982). Studies have shown that although elk are primarily grazers, their use of an area was higher when shrubs were intermixed with forest stands or where forest stands contained more than one successional stage (Lonner 1976). Ecotones provide a greater variety of forage plants used by elk, and more plants occur at a variety of phenological stages because of differences in microclimates where habitat types are intermixed (Skovlin 1982).

With the exception of the population in the Madison River drainage in and adjacent to YNP (Craighead et al. 1973), elk in the GYA are migrators, tending to return to the same winter and summer ranges year after year (Peek 1982). Although they are not migratory, the Madison River elk do exhibit seasonal changes in habitat use (Craighead et al. 1973). Migrating elk often follow the same travel routes, which are determined by topographic features and natural travel lanes (Adams 1982). Although movement to winter range is dictated primarily by increasing snow depth and density at higher elevations (Adams 1982, Farnes et al. 1999), summer and winter ranges fulfill differing habitat needs for elk.

SUMMER RANGE

Because of their large body size, elk have a relatively slow fattening rate, so summer range and the pulse of vegetative productivity between spring and the rut in autumn is of great importance in their ability to build up reserves with which to survive the winter (Geist 1982). Adult female elk face serious energy demands during lactation (Nelson and Leege 1982), which occurs while they are on spring and summer range. Grass is the most important forage type for elk during the spring greenup months, usually making up more than 85 percent of their diet (Nelson and Leege 1982). Grasses, forbs, and browse are all used to varying degrees during the summer, depending on availability (Kowles 1975, Nelson and Leege 1982). Leaves of browse species may also be consumed (Peek 1982). In addition to providing high quality forage, spring and summer range must provide opportunities for escape from biting insects as well as shade for escape from heat stress. Interspersion of cover to open areas appears to be important in determining calving areas because of the need for hiding sites used by newborn calves (Peek 1982).

WINTER RANGE

Snow depth and snow characteristics appear to be the driving factors in the timing and rate of elk migration to winter range (Lovaas 1970, Adams 1982). Characteristics important in elk use of winter range include areas of low snow cover to facilitate movement and access to forage, escape cover from predation, and security from harassment and associated energy expenditures. Areas used by elk in winter are often low elevation valleys where snow accumulations are low, but may also include windblown ridgetops and thermal areas and thermally influenced habitats where snow depths are generally low and some green vegetation may be found year-round (Craighead et al. 1973). Adult females, calves, and younger elk of both sexes generally winter in large groups in low elevation habitats (Adams 1982). Some females calve while on winter range, in which case hiding cover for calves is of critical importance as described above. Adult male elk generally seek widely dispersed small patches of habitat providing nutritious forage that will build up lost energy reserves and recover from injuries incurred during the rut (Geist 1982). Bulls are often found on the fringes of winter range occupied by cow/calf groups (Peek 1982) or at higher elevations and in areas of greater average snow depth. This separation of the sexes on the winter range may help to reduce competition for limited forage (Peek 1982). Elk diets on winter range are influenced strongly by forage availability, which is in turn affected by snow depth and density. In general, elk prefer to consume dried grasses during the winter, followed in preference by browse species and then conifers (Nelson and Leege 1982).

HUMAN ACTIVITIES

Elk face many obstacles in surviving the winter, some of which can be compounded by the impacts of human activities. Winter is an energetically difficult time, in which elk must carefully balance energy expenditures against energy intake in order to survive. Forage quality is lower in the winter than at any other time of year. In experimental feeding trials most elk lost weight on diets that mimicked winter diets (Nelson and Leege 1982). Winter habitat quality may play an important role in the reproductive success of females. The overwinter nutritional condition of elk has been correlated with reproductive success. Thorne et al. (1976) correlated high winter weight loss in pregnant females with prenatal calf loss, low calf birthweight, and low survival of newborns. Poor winter diet may also be associated with poor milk production (Taber et al. 1982). Adult males usually enter the winter in relatively poor condition and often injured as a result of rutting activity in the fall (Geist 1982). Quality of winter habitat alone may determine whether some males survive the winter, when forage quality is at its lowest and often is least accessible (Geist 1982). Up to approximately 87 percent of the daily forage consumed by an elk in winter is used for standard metabolic function, leaving less than 15 percent for growth, reproduction, temperature regulation, and activity (Nelson and Leege 1982). Because of the low quality of winter forage, elk often rely on reducing energy expenditures to increase their chances of surviving and successfully reproducing (Marchand 1996). Movement through snow is energetically costly for elk, becoming considerably more costly as snow depth exceeds knee height (Halfpenny and Ozanne 1989). Farnes et al. (1999) reported that when snow-water equivalent, a measure of snow density, reaches 6 inches, elk are generally unable to continue foraging in that area and must move to areas of lower snow depth or density. Elk are apparently unable to crater through snow deeper than approximately 40 cm in search of food, and at greater depths they may switch to foraging on browse (Marchand 1996), which is generally a poorer quality food than grasses. After elk have foraged in an area, the disturbed snow around craters often becomes very dense and precludes further foraging in that area, forcing elk to seek other areas or other sources of food (Farnes et al. 1999).

Elk rely on fairly restricted winter ranges in which food and cover may be limited or of marginal quality, and, consequently, any activity preventing them from using all or part of that range could have negative impacts on their ability to survive or to successfully reproduce. In many areas within the GYA historic winter range has been settled by humans and converted into developments or agricultural uses. Human settlement on historic winter range may decrease the quality or availability of winter range, through changes in habitat, increased harassment by humans, or competition with livestock (Skovlin 1982, Taber et al. 1982). The NER was created in response to the fact that much of the historic winter range in the Jackson Hole area had been converted to agricultural and other uses, depriving elk of critical habitat needed to survive the winter. Human settlement in the GYA may already have restricted some elk herds to smaller or less productive winter ranges, putting them at greater risk of negative impacts from other forms of disturbance or displacement. Cows with calves generally winter at lower elevations than do bulls (Adams 1982), but low elevation valleys and river corridors are also the areas most often used by humans for settlement, agriculture, and road-building (Glick et al. 1998). Elk in the Madison–Firehole elk herd are extremely restricted during the winter, surviving in small patches of thermally influenced habitat along the Madison and Firehole river corridors (Craighead et al. 1973, Aune 1981). The groomed road between West Yellowstone and Old Faithful, however, transects the core of this critical winter habitat (Aune 1981).

Some research has been conducted into the effects of disturbance on elk behavior and movements. Elk in some areas have apparently changed traditional travel routes in response to human settlement and to hunting pressure, particularly on winter range (Picton 1960, Kimball and Wolfe 1974, Smith and Robbins 1994). Logging activity in some areas has increased year-round access for recreationists into elk habitat, which in some areas has resulted in changes in elk distribution (Skovlin 1982). Declines in elk use of areas within 0.25–1.8 miles of roads have been reported, with distances varying according to the amount and kind of traffic, quality of the road, and density of cover adjacent to the road (Lyon and Ward 1982). Avoidance of roads results in habitat near roads becoming effectively unavailable to elk (Lyon 1983). Ward et al. (1976) and Hieb (1976) state that harassment can be of concern because elk will readily desert productive habitats when disturbance is excessive.

When elk groups crossing highways en route to winter range are interrupted by traffic, they have been observed spending a great deal of time searching for the rest of the group before continuing directional travel (Adams 1982). Logging roads with associated debris piled along the edges have proven to be barriers to elk movements in some areas (Lyon and Ward 1982). This is likely to also be true of snow berms piled along plowed roads during the winter. Elk flight distances in reaction to humans varies by season, habitat, conditioning, and type of human activity (Skovlin 1982). When elk are disturbed by hunters, they may travel long distances before stopping (Adams 1982), sometimes up to 8 miles before reaching security cover or protected areas (Altmann 1958). Solitary elk appear to have longer flight distances than do groups (Skovlin 1982). Elk experience an accelerated heart rate during the alert state immediately preceding flight caused by harassment, car horns, gunshots, and sonic booms (Ward and Cupal 1979), but elevated heart rate has rarely been linked to changes in reproduction or survival (Ferguson and Keith 1982). Repeated flight, however, particularly through deep snow, uses energy reserves that might otherwise be used to help elk survive the critical final weeks of winter (Skovlin 1982). Lyon and Ward (1982) reported that logging activity occurring on elk winter range results in less movement by elk than logging activity on summer range does, possibly due to the reduced vigor of elk during winter, the difficulty of movement in deep or crusted snow, and the lack of alternative areas to which to move. Aune (1981) also observed that in YNP, elk were less likely to flee from snowmobiles or skiers late in the winter than they were earlier in the season. He suggested that this was likely due in part to habituation by elk to snowmobile traffic, and in part to decreased vigor of elk later in the season combined with the increasing difficulty of flight through deep, crusted snow. Proximity of escape cover that breaks the line of sight between elk and the disturbance may reduce flight distances and consequently the amount of energy used in flight. Moving automobiles and trail bikes had little effect on elk resting in timber at distances of only 0.13 miles (Lyon and Ward 1982).

Findings from studies of elk behavior in response to specific human winter recreational activities are varied. Ferguson and Keith (1982) researched the influence of cross-country ski trail development and skiing on elk and moose distribution in Elk Island National Park in Alberta, Canada. They found no indication that overwinter distribution of elk was altered by cross-country skiing activity. However, it did appear that elk moved away from ski trails, particularly those that were heavily used, during the ski season. Anecdotal observations indicate that elk may be relatively sensitive to the sight and sound of snowmobiles, moving away when only a few machines are present (Bureau of Land Management, unpublished data in Bury 1978). Anderson and Scherzinger (1975) reported that when recreational snowmobile activity increased in the Bridge Creek Game Management Area in northeastern Oregon, winter elk counts decreased by 50 percent. After the area was closed to snowmobiling, the population returned to its previous numbers. Aune (1981) found that heavy snowmobile traffic in YNP occasionally inhibited free movement of wildlife, temporarily displacing them from certain areas. The most significant impact on wildlife distribution appeared to be within 60 m of groomed snowmobile trails. Aune (1981) also reported that snowmobile activity in YNP resulted in average elk flight distances of 33.8 m, compared to average flight distances of 53.5 m in response to skiers. In another study, elk began to move when skiers approached to within 15 m in an area heavily used by humans year-round, and within 400 m in an area where human activity is much lower (Cassirer et al. 1992). Elk in YNP fled more frequently and over greater distances from skiers off established trails than from skiers on established trails (Aune 1981). During winter in Rocky Mountain National Park, elk were relatively undisturbed by visitor activities occurring on roads, but they exhibited longer flight distances from an approaching person than from an approaching vehicle (Shultz and Bailey 1978). Ward (1973) reported that elk are easily conditioned to repeated patterns of human activity, but tend to be disturbed by deviations from normal patterns. In YNP, Aune (1981) found that wildlife species, including elk, were more likely to be displaced by or exhibit flight responses to snowmobile traffic during the preseason when traffic was limited to occasional administrative travel than they were to the heavier traffic occurring during the recreational season. This may have resulted from habituation by elk to the presence of snowmobile traffic and to establishment of a more constant traffic pattern during the recreational season. This change in response may also have resulted from decreasing physical condition of elk later in the winter, and increasing snow depth and crusting that inhibited flight. Elk also demonstrated a shift to a more crepuscular activity pattern when recreational snowmobile activity increased (Aune 1981).

It has been suggested that the presence of groomed ski and snowmobile trails may provide a means for energy efficient travel for elk and other wildlife during winter. Ferguson and Keith (1982) found no indication that elk used groomed ski trails as preferred travel routes in Elk Island National Park, Alberta. Elk in the Madison–Firehole and Gibbon River corridors of YNP used groomed snowmobile trails increasingly as snow became deeper and more crusted and as animal condition declined through the winter (Aune 1981). Trails created by only one or two passes of a snowmobile and ungroomed ski trails, however, were not compacted sufficiently to support the weight of an elk and consequently were not used. Elk suffer greater chances of mortality from vehicle collisions when using roads and trails, particularly if they become trapped by plowed snow berms or other obstacles along road and trailsides.

POTENTIAL EFFECTS

Winter recreational activity can result in a variety of impacts on elk, depending on the nature and duration of the activity and the condition of the affected animals. Elk may readily habituate to predictable activity, so that recreational activities taking place on well-established routes and over a predictable time interval may have little effect on them after they become accustomed to the activity. Elk may learn to avoid areas of continual noise or disturbance, however, effectively removing a portion of otherwise available habitat from their use. This avoidance can have negative impacts on elk by reducing the amount or type of forage available and thereby adding to nutritional stress. Human activity occurring in low-snow areas may impact elk primarily because those areas are likely to be favored by elk late in winter when they are in poor condition. Antler hunting, for example, is an extremely popular activity during the late winter in many portions of elk habitat in the GYA, particularly on the northern range. This activity places humans generally on foot or horseback in low-snow winter range areas where bulls may be concentrated late in winter. The generally unpredictable, off-trail nature of this activity has the potential to create significant disturbance and stress to bull elk at a time when their energy reserves are at their lowest.

Conversely, elk may learn to use groomed roads or trails, and plowed roads as energy-efficient travel routes during the winter. It is not known whether the energy savings of using plowed and groomed roads and trails is greater or less than the costs of disturbance encountered while using such travel routes. Plowed roads may represent barriers to movement by elk if there are high snow berms on either side of the road, and may contribute to vehicle-caused mortality of elk using roads or trails. Roads may also provide energy efficient means of travel for predators in winter, increasing their ability to access prey and thereby increasing vulnerability of prey species such as elk.

Activities occurring in unexpected places or at unexpected times, such as skiing on lightly used trails or off-trail skiing, off-trail snowmobile use, or opening of previously closed areas can cause elk to flee, thereby using valuable energy reserves. Flight may be particularly costly for elk if snow is deep or crusted, or if elk are already in nutritionally stressed condition. Activity that occurs repeatedly but unpredictably may result in cumulative energy use over the course of the winter that might compromise an elk's ability to survive or reproduce. Repeated disturbance that does not result in flight may create stress in the form of increased heart rate and hormonal and other physiological changes, but any effects that these changes may have on overall survival and reproduction have not been well researched. The effects of disturbance by humans may be lessened if adequate hiding cover is available nearby. Disturbances that occur late in winter, when elk are in their poorest physical condition and the forage supply may be depleted, are likely to have a more negative impact than those occurring earlier in winter. Inability of elk to move through late-winter deep and crusted snow may compound the stress associated with disturbance at that time.

Elk in the GYA are likely to be affected by human use of the following Potential Opportunity Areas:

(1) Destination areas. If such areas are newly created within elk winter range, they have the potential to displace elk from needed habitat. Elk may become accustomed to activity at destination areas if that activity is predictable. Irregular human activity at such areas may prompt flight response by elk in the vicinity.

(2) Primary transportation routes and (3) scenic driving routes. Transportation routes are often located in low-elevation areas and along river corridors, areas also often used by elk for travel and winter range. Habitat may become unavailable to elk through construction of transportation routes and through avoidance by elk of transportation corridors, particularly those that are heavily used. Routes with heavy traffic use or physical barriers along roadsides may interfere with elk travel and migration patterns. Vehicle collisions may result in mortality of individual elk.

(4) Groomed motorized routes and (5) motorized routes. Groomed routes are likely to have impacts similar to those of primary transportation routes and scenic routes, depending on the level of human use. Groomed routes may provide an energy efficient travel route for elk, but may also do the same for predators of elk.

(6) Backcountry motorized areas. Human activity in backcountry areas is likely to be less predictable than in other motorized recreation areas and, therefore, has more potential to create flight response in individual elk or groups of elk. Motorized use of these areas is likely to occur over a less-confined area than transportation routes, potentially increasing the area of disturbance or displacement of elk. This type of recreation usually occurs in higher elevation, deep-snow areas and so may impact only scattered groups of adult males.

(7) Groomed nonmotorized routes and (8) nonmotorized routes. If use of these areas is predictable and confined to a defined area, elk may become habituated to the human activity occurring there. Nevertheless, elk could be displaced from areas immediately adjacent to groomed routes, and individuals or groups of elk may be prompted to flee from humans using such routes. Elk are more likely to flee from activity occurring on ungroomed routes because of the unpredictable nature of that use. Use of nonmotorized routes is, however, likely to be less frequent than that of groomed routes.

(9) Backcountry nonmotorized areas. Although use of these areas is unpredictable and, therefore, likely to produce flight response in elk, this type of use is likely to be infrequent enough to prevent recurrent stress of elk wintering in these areas. Backcountry skiing areas are also likely to be in higher elevation, deep-snow areas where fewer elk groups winter.

(10) Downhill sliding (nonmotorized). These areas are likely to be limited in number and size and are likely to be located adjacent to roads or groomed motorized trails. Disturbance associated with these areas is likely to be only slightly increased over disturbance from the transportation route used to access them.

(12) Low-snow recreation areas. One of the primary characteristics in elk choice of wintering areas is low snow depth. Therefore, human activities in these areas have potential to displace elk from important winter range. Elk may completely avoid such areas if human use is heavy or unpredictable, thus depriving them of access to forage and easy travel routes. Although habituation is possible to activities occurring in a predictable fashion, disturbance by humans can cause repeated flight response, causing stress and energy consumption by elk. Cows and calves generally winter in low-snow areas, and those affected by continued disturbance or displacement may suffer decreased reproductive success or ability to survive harsh winters.

MANAGEMENT GUIDELINES

- Avoid construction of new facilities in elk winter range and place any necessary construction in or adjacent to already disturbed areas. Elk winter range in many parts of the GYA is being converted to developments and other uses, so additional removal of winter habitat should be avoided.
- Regulate human activities so that they occur in defined areas in as predictable a fashion as possible. Elk may become habituated to regular human activity, decreasing flight response and consequent energy expenditure. Generally, moving traffic creates less disturbance than destination points or areas where humans are out of vehicles.
- Structure areas of human use and development so that there are buffer zones between humans and elk-use areas. Create or maintain sight barriers (brushy or forested areas) adjacent to human-use areas, thereby reducing the distance elk must flee to find hiding cover.
- Avoid placing transportation and motorized routes in low-elevation, low-snow, riparian, and open habitats favored by elk. Where this is necessary, attempt to occasionally move the route away from those areas and through denser timber or areas with adequate hiding cover. Avoid creating roadside barriers that may prevent elk from crossing roads or trails or that may trap animals along the route.
- Limit human activity in low-snow winter range areas. Where it occurs, keep activity concentrated in established areas.
- Consider limiting or removing livestock from low-snow wintering areas where they compete with elk, in order to mitigate for habitat losses occurring through developments on elk winter range in other areas.
- Carefully research elk use of particular areas before creating new human activity zones. Avoid creating new developments or disturbances in areas where elk have no alternative winter range to use or where impacts cannot be adequately mitigated.

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EFFECTS OF WINTER RECREATION ON GRAY WOLVES

POPULATION STATUS AND TREND

Gray wolves *(Canis lupus*) were once distributed throughout North America and were native to the Yellowstone area (Bangs and Fritts 1996). In the conterminous United States, they were extirpated to 3 percent of their historical range (Fuller et al. 1992). In the Greater Yellowstone Area (GYA), wolves were eliminated by the mid-1930s as a result of systematic predator control (Weaver 1978).

Following the approval of the 1994 environmental impact statement on the reintroduction of gray wolves into the Yellowstone and central Idaho ecosystems, wolves were reintroduced to these areas in 1995 and 1996 (USFWS 1994). Although wolves are classified as “endangered” in Montana, Idaho, and Wyoming under the Endangered Species Act of 1973 (USC 1531, 1982 amend.), they were reclassified as “experimental/non-essential populations” in the Yellowstone and central Idaho ecosystems before they were reintroduced to allow more flexibility in managing the species. This designation allows government agencies more options for relocating or removing individual wolves preying on livestock (USFWS 1994).

In 1995, 14 wolves were reintroduced into Yellowstone National Park using three “soft release” pen sites; 17 additional wolves were reintroduced to the park in 1996, and four pen sites were used (Phillips and Smith 1997). In January 1999, there were approximately 116 wolves in at least seven packs within the GYA (Bangs et al. In Press).

LIFE HISTORY

Wolves are highly social and hierarchical, and they live in family groups called packs. Packs consist of the dominant or “alpha” breeding pair, their recent litter of pups, and other adult and subadult individuals (Mech 1970, Tilt et al. 1987). During early spring (mid-March to early April), wolf packs excavate a den and rear a litter of pups. Average estimated birth date for wolf pups in the Yellowstone area in 1995 and 1996 was April 24 (Phillips and Smith 1997); pups are nursed six to eight weeks. At one to two years of age, a young wolf leaves the pack and tries to form its own pack.

Wolves depend upon ungulates for food. In the Yellowstone area, the primary prey for wolves is elk (87%); other prey includes moose, deer, antelope, and bison (Phillips and Smith 1997). Wolves prey on ungulates throughout the year (Tilt et al. 1987), and use ungulate carcasses (elk and bison) during early spring prior to denning. The peak period of availability of carcasses occurs about mid-April (Green et al. 1997; D. Smith, Yellowstone National Park, personal communication).

HABITAT

Wolves are not habitat specific and use much of the landscape within their pack’s established territory (Mladenoff et al. 1995), however, snow depth and condition can influence wolf movements in the winter (Mech 1970, Paquet et al. In Press). Winter foraging occurs primarily on ungulate winter range. The ungulate winter range is also the key spring habitat for wolves as most winter-killed carcasses are found here.

HUMAN ACTIVITIES

Winter recreation has the potential to affect gray wolf movements and habitat use during the period of winter foraging and early spring denning. In the GYA, winter foraging typically occurs on the following ungulate winter ranges: the Yellowstone northern range (Mack and Singer 1992), the North Fork of the Shoshone River, the Jackson Hole basin, the Clarks Fork River (Boyce and Galliard 1992), and the areas that are geothermally influenced within Yellowstone National Park (Green et al. 1997).

Some information exists on specific effects of winter recreation on gray wolves. Most information, however, is available from data on the effects of other human activities. Paquet et al. (In Press) found that winter movements of wolves in Canadian parks were influenced by human activities. Winter activities that compact snow cover, such as snowmobiling, cross-country skiing, and maintenance of winter roads, provided feasible travel routes for wolves into areas that were usually inaccessible because of deep snow (more than 15.5–19.5 inches). The consequences of this are that there may be modifications to wolf/prey interactions and habitat use as well as differences in landscape movements between groups of prey (Paquet et al. In Press).

Studies of snowmobile use and wolf movements in Voyagers National Park (NPS 1996) have shown that wolves tended to avoid areas of snowmobile activity in restricted-use areas. The studies also showed that repeated avoidance or displacement could result in permanent displacement, an impact to an animal’s winter energy budget, and/or a conditioning of the animal to avoid certain areas. While the study did not prove that winter recreational use harmed wolves, it suggested that the National Park Service should close important wolf foraging areas to winter use until a better understanding of wolf–snowmobile interactions could be determined.

Other studies have documented similar responses by wolves in the avoidance of roads. In Kenai National Wildlife Refuge, radio-collared gray wolves avoided year-round access roads open to public use and were attracted to roads that were closed or were managed for limited human use. Wolves used low-use roads as travel corridors (Thurber et al. 1994). Wolf avoidance of settled areas and public roads in this study area was more a result of behavioral avoidance rather than direct mortality of animals. In Jasper National Park, wolves avoided traveled roads and were negatively affected by disturbance at den sites (Carbyn 1974). In Yellowstone National Park, wolves use areas near groomed snowmobile roads because there are ungulates wintering in the vicinity. On one occasion in 1997, wolves initially used an elk kill along a groomed snowmobile road and then left it when humans were present (D. Smith, Yellowstone National Park, personal communication).

Developments in Canada were shown to negatively affect wolves in Banff, Yoho, and Kootenay national parks. In Banff National Park, the town of Banff partially blocks natural wolf movement, denying access to prime habitat east of town (Purves et al. 1992).

POTENTIAL EFFECTS

Winter recreation has the potential to affect gray wolves during winter foraging and denning periods. Potential wolf/human conflicts could occur in winter foraging habitats, along snowmobile and ski trails, or near developments. The literature shows that wolves both used and avoided roads and trails designated for winter use. Although wolves use snowmobile trails for travel and foraging, they avoid roads, trails, and facilities if humans are present. The ecological significance of altering natural movement and foraging patterns is not fully known. Human activity during late winter/early spring could also displace wolves during the sensitive denning period.

Gray wolves in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(1) Destination areas. Wolves may avoid habitats near winter developments when they occur on or near important ungulate winter ranges and when the developments remain open during spring denning periods (early to mid-April). This is especially critical when developments occur in or near high-quality winter and spring habitats that may include geothermally influenced winter range, low-elevation winter range, and other areas where winter-killed carcasses are found.

(2) Primary transportation routes and (3) scenic driving routes. Primary roads may affect wolf populations by fragmenting pack movement and causing direct mortalities. Five wolves were killed by vehicles in Yellowstone National Park between 1995 and 1997 (Gunther et al. 1998).

(4) Groomed motorized routes. Conflicts could occur when routes groomed for snowmobiles bisect habitats used by wolves in the winter, affecting wolf movements and foraging patterns. Moreover, grooming of roads and trails may affect ungulate movements (Meagher 1993), and this may influence wolf movements as well (Paquet et al. In Press). Areas of particular concern are ungulate concentration sites where winter-killed carcasses are available. These include both geothermally influenced and low-elevation winter ranges.

(6) Backcountry motorized areas. Wolf activity could be affected in ungroomed areas used by snowmobiles. Although areas of ungroomed snowmobile use typically occur at high elevations where wolves do not occupy winter habitats, there is potential for conflicts between wolves and recreationists if winter snowmobiling occurs on low-elevation or geothermally influenced ungulate winter range. Impacts would also occur if wolves were deliberately chased by recreationists on snowmobiles.

MANAGEMENT GUIDELINES

- New winter recreational developments should not be built near ungulate winter ranges or where they would impede wolf movements between high-quality habitats. Moreover, existing destination areas should be closed by April 1 to prevent the displacement of wolves during critical denning periods.
- By definition, year-round routes will remain open whether winter recreation occurs or not. Wildlife managers should immediately remove road-killed animals from roadsides to prevent foraging wolves from being hit by vehicles.
- New groomed motorized routes should be located in areas that are not classified as ungulate winter range or important wolf habitat. Grooming and use of snowmobile roads and trails should end between March 15 and April 1, allowing wolves to use spring denning sites without harassment. Human use of geothermally influenced winter ranges in the Firehole, Gibbon, and Norris areas of Yellowstone National Park should be managed during winter in a manner that allows wolves to forage; human use may cause displacement from these high quality habitats.

- Dispersed motorized use should not occur on or near ungulate winter range or on spring range after wolf denning begins, usually between March 15 and April 1.

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EFFECTS OF WINTER RECREATION ON GRIZZLY BEARS

POPULATION STATUS AND TREND

Historically, grizzly bears *(Ursus arctos horribilis)* ranged throughout most of western North America. Today, only a fraction of historic population levels occupy a remnant of their former distribution range (USFWS 1993). Loss or degradation of habitat in conjunction with unregulated hunting and livestock depredation control are cited as the main factors contributing to their decline (USFWS 1993). Grizzly bear populations have persisted only where large areas of public land maintained in a natural state provide necessary habitat components. Limited and/or regulated human activity has proven to be a requirement for the maintenance of grizzly populations (Mattson 1990). Today, there are six recovery zones designated within the conterminous United States (USFWS 1993). One of these zones includes a portion of the Greater Yellowstone Area (GYA), where a self-perpetuating grizzly bear population exists.

Under the authority of the Endangered Species Act (ESA), the U.S. Fish and Wildlife Service listed the grizzly bear as a threatened species in 1975. Recovery goals for the Yellowstone grizzly have since been established (USFWS 1993). However, the bear's long-term future remains uncertain and controversial. Threats to its existence are numerous (Picton et al. 1985, Mattson and Reid 1991, Eberhardt et al. 1994, Eberhardt and Knight 1996). In addition, determining population size and the characteristics used as a basis for trend predictions have been problematic (Schullery 1992, Eberhardt et al. 1994, Eberhardt and Knight 1996).

The grizzly bear population declined in the early 1970s following the closure of open garbage dumps and subsequent human-caused mortality around the GYA. Since then, trend data indicate a modest population increase (Eberhardt and Knight 1996). While grizzly bear mortalities, including human-caused deaths, have varied widely in the GYA during the past decade, cub production has increased (Eberhardt et al. 1994, Eberhardt and Knight 1996). A turning point in the earlier trend came in the mid-1980s when government agencies committed substantial resources toward the goal of preventing adult female grizzly bear mortality and protecting important grizzly bear habitat (Eberhardt et al. 1994, Gunther 1996).

Human-caused mortality of grizzlies, especially females, continues to be of particular concern in the recovery of this species; direct human-caused mortality is the cause of virtually all grizzly bear population declines and extinctions (Mattson 1993). There are several factors that complicate efforts to deal with this issue. It is impossible to predict the number of bear mortalities that will occur in a given time frame, and the range of variation from year to year can be large. Although the grizzly population may be increasing, human use of the GYA is also increasing. This means the potential for bear–human conflicts and human-caused mortalities persist and will probably grow.

Numerous researchers have analyzed grizzly bear mortality data for the GYA (Povilitis 1987, Craighead et al. 1988, Knight et al. 1988, NPS 1988). Their findings indicate that most grizzly bear mortalities since 1974 involve humans and can be classified as either illegal shootings or management-control actions. Povilitis (1987) found that almost half of the mortality risk was associated with people carrying firearms on national forest lands. Within Yellowstone National Park, almost all grizzly bear mortalities were the result of management actions by the National Park Service against habituated, human-food-conditioned grizzlies (Gunther 1994).

Knight et al. (1988) reported that known and probable deaths of grizzly bears tend to be centered around specific areas in and around Yellowstone National Park. They described these as "population sinks" and identified them as the gateway communities surrounding Yellowstone National Park, major development areas within the park, sheep grazing allotments, and various other human concentration areas.

One of the major problems associated with human development in occupied bear habitat is the availability of attractants (garbage and human and pet food). Human garbage is cited as one of the major contributors to bear conflicts with humans (Herrero 1985). If food is obtained at one of these sites by a bear, the bear may periodically check the site for more food. The bears that are thus conditioned are often the target of management actions and usually become mortalities.

Bears are also killed by illegal shooting. These shootings may be categorized as self-defense, defense of property, hunters mistaking grizzlies for black bears, and poaching. An increase in people in areas where there are bears increases the likelihood of mortalities by shooting. There are other issues to consider in the long-term status of the Yellowstone grizzly bear. The population may reach carrying capacity, causing a decrease in subadult survival (Eberhardt and Knight 1996). Available food may be reduced by climatic change (Picton et al. 1985, Mattson and Reid 1991), loss of whitebark pine from blister rust infection (Kendall and Arno 1990, Mattson and Reid 1991), and a decrease in Yellowstone cutthroat trout as a result of whirling disease and competition with lake trout (Varley and Schullery 1995).

LIFE HISTORY

Much is known about the life history of the Yellowstone grizzly bear (McNamee 1984). However, only those details that relate to the topic of winter recreation use will be mentioned here. Cubs are born in the den from late January to early February. They are helpless and rely on the mother for warmth and nourishment. The average litter size is about two (Schullery 1992). This is a time when both mother and offspring are especially vulnerable (Reynolds and Hetchel 1980).

HABITAT

DENNING

In a five-year study of Yellowstone grizzly bears in the late 1970s, November 9 was found to be the mean entrance date for 70 bears tracked to their dens. The earliest entrance date recorded was September 28 for a pregnant female and the latest was December 21. Pregnant females entered dens earliest, but differences in the mean denning dates of sex and age groups other than pregnant females were not significant. Bears frequented the immediate area of den sites from 8 to 22 days before entering (Judd et al. 1986).

Male grizzlies were usually the first to leave their dens, emerging between mid-February and late March. The other population segments generally emerged in the following order: single females and those with yearlings and two-year-olds followed by females with new cubs. The last group emerged between early and mid-April (Judd et al. 1986).

Judd et al. (1986) concluded that bears did not seek den sites in open areas or show strong preference for a specific type of canopy coverage; however, sites with whitebark pine and subalpine fir appeared to be preferred for dens. Both tree species are found at higher elevations. Elevation of dens ranged from 6,500 to

10,000 feet; and the average elevation was 8,100 feet, with an apparent clumping in the range of 8,000 to 9,000 feet.

Dens were found on all aspects, but there was an apparent preference for north exposures. Most dens were found in the 30 to 60 degree slope range. Some dens were reused, but others collapsed after a season of use (Judd et al. 1986).

Judd et al. (1986) concluded that availability of denning sites did not appear to be a critical element of grizzly bear habitat in the Yellowstone area since grizzly bears appear to be able to use sites with a wide range of environmental characteristics. In addition, given the amount of protected habitat in Yellowstone National Park and the surrounding national forest wilderness areas as well as the large size of a grizzly bear's home range, they did not think den sites would become scarce in the foreseeable future.

Denning studies in Canada, Alaska, and the Northern Continental Divide Ecosystem (IGBC 1987) indicate that while there are differences in entry and emergence dates, there is commonality in the data on den characteristics. These data also indicate the adaptability of grizzly bears in den site selection and a strong fidelity to denning areas. Although den re-use has been documented in many areas, it is not considered common; however, returning to a denning area is. These denning areas apparently possess characteristics that make them favorable, and some individuals remain traditional in using them (IGBC 1987).

PRE-DENNING AND POST-EMERGENCE

The activity of grizzly bears before denning and after emergence follows a predictable pattern that is determined by feeding behavior. The food habitats of Yellowstone grizzly bears are summarized in Knight et al. (1984) and Mattson et al. (1991). These investigations show that grizzly bears are opportunistic feeders that use a wide variety of animal and vegetal food items. Although diet varies as much by season as by month, trends are discernible. The main items in the diet of Yellowstone grizzly bears are whitebark pine nuts and ungulates. Grizzly bears obtain a substantial portion of their energy from ungulates in the spring (Mattson 1997). This food source is estimated to be one of the top two sources of energy in the average diet, especially during March, April, May, September, and October (Knight et al. 1984). Carrion scavenged from March through May constitutes a major portion of this ingested meat (Mattson et al. 1991), with peak availability of carcasses occurring around mid-April (Green 1994, Green et al. 1997).

In fall, bears aggressively forage to store fat for winter. This pursuit is called hyperphagia and is characterized by a determined attempt to increase calorie intake. The most important fall diet item for Yellowstone grizzly bears are whitebark pine seeds. Because the need for food is so intense, bears may approach areas of human activity that they would ordinarily avoid during this time when whitebark pine seeds are not available (Mattson 1990, Mattson et al. 1992).

In spring, bears leave their denning sites at higher elevations and search for carrion from winter-killed bison and elk. Therefore, key spring habitats for Yellowstone grizzly bears are ungulate winter ranges (Mattson 1997). Bear use of ungulate carcasses during spring varies among habitats. Green (1994) found that grizzly bear use of spring carcasses increased with elevation and that bears were more likely to use carcasses in the geothermally influenced habitats of the Firehole–Gibbon and Heart Lake areas than in the low-elevation areas of the Yellowstone northern range. This occurred even though most spring carrion in Yellowstone National Park was found on lower elevation ungulate winter range (Green 1994, Mattson 1997, Green et al. 1997).

Various studies have indicated that live ungulates are used as food when they are most available and vulnerable, as weakened animals during the spring (Henry and Mattson 1988, Green et al. 1997), as calves during May and June (Gunther and Renkin 1990), or as weakened bulls during the fall rut (Schleyer 1983). A few grizzlies have learned to kill adult elk during the summer (Servheen and Knight 1993).

Another high-energy diet item for Yellowstone grizzly bears following den emergence is whitebark pine seeds. Whitebark pine seeds are an energy-rich bear food typically found at higher elevation forest stands during the fall (Mattson and Reinhart 1994). However, after a high whitebark pine cone crop, cones will remain available during the following spring. As a result, bears will forage in these higher-elevation habitats, apparently preferring this food item to carrion (Mattson 1997, Green et al. 1997).

HUMAN ACTIVITIES

Judd et al. (1986) acknowledged that a deficiency in their investigation of grizzly bear denning activity in the GYA was the lack of insights gained on the impact of humans to bears during this period in their lives. The den sites they investigated were remote from humans at all times of the year, and there was no opportunity to address this issue.

One of the few studies that did deal with this topic was conducted in Alaska. It considered the impact of winter seismic surveys and small fixed-wing aircraft on denning grizzly bears (Reynolds et al. 1984). Grizzly bears used in the study were radio-collared or had heart-rate transmitters implanted. Potential sources of disturbance included the sounds of aircraft, sounds of operating vehicles (track-mounted drill rigs, geo-phone trucks, survey Bombardiers, snow machines, support trains), and sounds of shock waves associated with the detonation of about 85 pounds of dynamite at approximately 100 feet below the surface.

Detonations conducted within a range of 0.8 to 1.2 miles of the bears did not cause them to leave the den. However, movements within dens were sometimes detected following blasts (Reynolds et al. 1984). When seismic vehicles passed within 5/8 mile of the den, the bear's heart rate was elevated much more often than when undisturbed (Reynolds et al. 1984). Circumstantial evidence indicated that an unmarked bear left its den when seismic activity was within 650 feet of the den, but tractors and tracked vehicles came within 325 feet of a denned female with 3 yearlings without causing den abandonment. Mid-winter over-flights of dens with small fixed-wing aircraft did not change the heart rates of two females denning with young; however, flights conducted closer to the time of den emergence did change the heart rates of bears. The authors concluded that even if animals did respond to noises associated with seismic exploration activities, effects on them were probably minimal at these distances and at this level of activity (Reynolds et al. 1984). None of the radio-collared bears deserted dens, and there was no evidence of mortality.

Other research shows varying effects of human use on hibernating bears. Harding and Nagy (1980) documented grizzlies successfully denning on Richards Island, Northwest Territories, in the general area of hydrocarbon mining activity. Of the 35 dens they located, 28 were within the potential impact area, including several within one to four miles of active mine areas. However, Goodrich and Berger (1994) demonstrated that black bears abandoned den sites in response to disturbance.

Reynolds and Hechtel (1980) speculated that agitation within the den could have serious consequences for females with newborn cubs. Watts and Jonkel (1989) supported this idea and added that the ability of bears to reduce energy output in the winter may be a function of the secure den environment. In addition, human disturbance during denning could accelerate starvation and has resulted in den abandonment. They concluded that poor quality den sites and adverse weather could elevate metabolic rates and increase energy demands. Also, Geist (1978) discussed the implications of energy expenditure for animals and noted that when they are excited, the energetic costs from increased metabolism and heart rate can be significant. Presumably, this would hold true for bears in a den.

By their nature, dens represent locations where bears concentrate activities. This raises the concern of bear–human conflicts around dens. However, there are few documented cases of people being injured by bears in the vicinity of den sites. Herrero (1985) concluded this type of behavior may be due, in part, to the fact that dens are consistently in remote areas less traveled by people.

To a greater extent, grizzly bears may be affected by human activity while foraging during the pre- and post-denning periods. The pre-denning and post-emergence periods are critical times for bears. In the first time frame, they are in an intense feeding mode to store fat for the winter, and in the second time frame they are in search of food after depleting their reserves over the winter.

POTENTIAL EFFECTS

The literature indicates that bears can be impacted by human activities in winter. There are three stages in the annual cycle of the grizzly bear when it is vulnerable to the impacts of winter recreation use: (1) pre-denning, (2) denning, and (3) post-den emergence. Because of this, it is important to address a longer time frame than the traditional winter months. For example, the pre- and post-denning periods for bears overlap the fall and spring seasons, respectively. Therefore, it is reasonable to consider the pre- and post-denning time for bears as biological events instead of restricting an analysis of effects to calendar dates.

By the nature of how some recreational facilities are managed, winter visitor use generates effects on grizzly bears in the fall and spring that would otherwise not occur. The existence of winter-use facilities and programs likely encourage additional public visitation in the shoulder seasons. Winter recreational effects on bears are thus contingent on when and where facilities open in the fall and close in the spring.

Destruction of den sites or denning habitat does not appear to be a major issue in the GYA at present or in the near future. Neither does disturbing bears while they are preparing or occupying dens, although the possibility exists. The main concern is the potential for bear–human conflicts and displacement of bears while they are foraging during the pre-denning and post-emergence periods. Specifically, this involves bears engaged in wide-ranging foraging efforts before denning, mainly near whitebark pine habitats. It also includes the use of ungulate wintering areas by bears seeking carrion after leaving dens, and, to a lesser degree, bears using over-wintered whitebark pine seed crops at higher elevations.

Grizzly bears of the GYA may be affected by human winter recreation use of the following Potential Opportunity Areas:

(1) Destination areas. Human activity at destination areas has the potential to negatively impact grizzly bears. This

is primarily in the context of the pre- and post-denning periods. For example, spring surveys of grizzly bear habitats have shown that bears generally used carcasses less often than expected within 3 miles of a major park development (Green et al. 1997). Moreover, when bears come in proximity to park developments, more bear management actions and subsequently more grizzly bear removals occur (Mattson 1990, Reinhart and Mattson 1990).

Winter destination areas are becoming more popular. They include major ski areas, resorts, developments in Yellowstone National Park, and park gateway communities. These areas have been historic population sinks for grizzly bears in the GYA (Knight et al. 1988). The potential for bear–human conflicts is high when winter developments remain open after bears emerge from hibernation and are using spring habitats (approximately March 15) (Green et al. 1997). This is especially critical when these developments occur in or near areas where winter-killed ungulates and over-wintered pine nut crops may be found (Mattson et al. 1992).

In addition, bears will seek attractants around human developments in the pre-denning period of hyperphagia when food is less available. Frequently, the result is bear–human conflicts. Mattson et al. (1992) concluded there is a relationship between the quality of the fall pine nut crop and the number of conflicts that occur. During years of widespread pine nut use, grizzly bears are seldom found in proximity to human facilities. However, during years of little or no pine nut use, areas near human facilities (less than 3 miles from roads and 5 miles from developments) were used intensively by bears. Also, managers trapped nearly six times as many bears and nearly two times as many bears were killed during years of low pine nut production. Presumably, this was a consequence of bears being nearer and in more frequent contact with humans while seeking alternate foods to compensate for the lack of available pine nuts.

(2) Primary transportation routes and (3) scenic driving routes. Year-round roads will exist regardless of winter recreation use. However, winter recreational use management may cause changes in the amount of traffic a road receives. It may also be a catalyst for creating new roads.

Winter vehicle use of year-round roads during the denning period does not pose a risk to bears. Bears and traffic are spatially separated during most of the winter, and bear behavior seldom brings them into contact with the road corridor. Bear attractants along roads in the pre- and post-denning periods do present a risk. This could occur at roadside trash collection sites or as deliberate feeding of panhandling bears. An additional concern is road-killed animals (usually ungulates or rodents) that may attract bears to the roadside where they are vulnerable to vehicle collision.

(4) Groomed motorized routes and (5) motorized routes. Snowmobile traffic alone on highly and moderately groomed routes does not present a significant impact to bears during

most of the winter months. This is because of the predictability of defined snowmobile corridors and because most snowmobile use occurs during the time that bears are in hibernation. Conflict could occur when snowmobile use coincides with spring bear emergence and foraging. The potential for bear–human conflicts in Yellowstone National Park during the spring emergence is exacerbated by the fact that park roads are often located near thermal areas where ungulates congregate in the winter. The geothermally influenced ungulate winter ranges in the Firehole, Gibbon, and Norris areas are good examples of locations where the risk of bear–human conflict in the spring is high.

(6) Backcountry motorized areas. Most use of ungroomed snowmobile areas should not conflict with bear activity because it coincides with bear hibernation. Moreover, areas of ungroomed snowmobile use typically occur at elevations above bear spring habitats. An exception is when overwintered whitebark pine crops are available, and bears forage at high elevations in the spring. Another possible effect may occur because most backcountry snowmobile use occurs at higher elevations, where most bear denning is found.

The potential for conflicts between bears and recreational users does exist when dispersed use occurs after bear emergence (between March 1 and March 15).

(7) Groomed nonmotorized routes. Skiing along groomed routes does not present a significant impact to bears during most of the winter months. This is because of the predictability of defined ski corridors and the timing of most skiing coincides with bear hibernation. Conflict could occur when skiing is at the same time as bear foraging in the post-den emergence period.

(8) Nonmotorized routes. Skiing and snowshoeing along ungroomed routes does not present an impact to bears during most of the winter months. This is because of the timing of most of this travel coincident with bear hibernation. Conflict could occur when travel coincides with bear foraging in the post-den emergence period.

(9) Backcountry nonmotorized areas and (10) downhill sliding. Backcountry skiing, showshoeing, and downhill sliding should not present an impact to bears during most of the winter months. Again, the potential for bear–human conflicts may occur during the late winter period after bears emerge from hibernation. A component of this is the risk of human injury resulting from surprise encounters in backcountry areas as people disperse across the landscape in a manner unpredictable to bears (Herrero 1985). A unique expression of this occurs in low-elevation ungulate winter range where people search for dropped elk antlers. In this case, people intentionally canvas all parts of the terrain and concentrate on areas where wintering and winter-killed elk are found.

MANAGEMENT GUIDELINES

- (1) Destination areas. Early and mid-December and early and mid-March should be used as a time for transition from a fall to winter and winter to spring management strategy, respectively. Appropriate actions include closing facilities, restricting human use in sensitive areas, improving sanitation, and providing public education. Management of developments should reflect recognition of an increased potential each spring for bear–human conflicts and displacement of bears foraging within important habitats.

On public land, developments can be regulated, but it is more difficult to address activities at developments on private land. In these cases, coordinated sanitation programs involving private interests and government organizations are needed to remove attractants year-round, with a special emphasis placed on securing attractants during the pre-denning period.

- (2) Primary transportation routes and (3) scenic driving routes. Good roadside sanitation should be maintained. Signing to inform motorists of the need to secure attractants should be provided.

  Carcasses should be removed from the roadside between March 1 to November 30. No new roads to accommodate winter recreational use should be built in grizzly bear habitat as more access would ultimately result in more bear–human conflicts.
- (4) Groomed motorized routes and (5) motorized routes. Grooming and use of snowmobile roads and trails should end by March 15 in areas where post-denning bear activity is high.
- (6) Backcountry motorized areas. Where winter use occurs in ungulate wintering areas, activity should end by March 15. In areas with whitebark pine forests, a primary issue is the displacement of bears. Because the presence of over-wintered pine nut crops is not consistent, this is an episodic and not an annual concern. Therefore, travel restrictions should be addressed based on yearly monitoring rather than as a continuous restriction.
- (7) Groomed nonmotorized routes. Depending on the observed risk, grooming and use of these routes should end between March 1 and March 15 in those areas where bears would potentially be drawn to forage. Sanitation procedures around associated support facilities should be strengthened and public education initiated during the same time frame.
- (8) Nonmotorized routes. Use should be curtailed or restricted depending on the observed risk between March 1 to March 15. Public education should be initiated during the same time frame.
- (9) Backcountry nonmotorized areas and (10) downhill sliding. Use should be curtailed or restricted depending on the observed risk between March 1 to March 15. Public education should be initiated during the same time frame.

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LYNX: THEIR ECOLOGY AND BIOLOGY AND HOW WINTER RECREATION EFFECTS THEM

POPULATION STATUS

Lynx *(Lynx canadensis)* historically occupied much of the northern portion of North America, but the loss and degradation of their habitat and the unregulated hunting and trapping that accompanied European settlement reduced their numbers and distribution in the conterminous United States (Jackson 1961, Ruediger 1994). Today, remnant lynx populations persist in some high-elevation boreal forests of the western and Great Lakes states, tied chiefly to the distribution and abundance of snowshoe hares (*Lepus americanus*) (Koehler and Aubrey 1994).

In 1999, the U.S. Fish and Wildlife Service (USFWS) is expected to list the lynx as a threatened species under the authority of the Endangered Species Act (ESA). The listing will culminate a series of actions that included a petition by conservation groups to list the species in 1992 and a series of court decisions. The action will require development of a recovery plan by the USFWS and also require that actions taken by federal wildlife and land-management agencies do not jeopardize the species' welfare. Lynx are already treated as a sensitive species by most federal and state wildlife management agencies in the western United States.

Montana is the only state in the contiguous United States that still allows trapping of lynx. There is currently a statewide quota of two lynx, with a limit of one per trapper per year. Trapper harvest peaked at 60 in 1979 but was reduced to two lynx per year by legislation. Trapper effort has also declined in spite of high lynx fur prices in the 1980s. Illegal and incidental harvest are thought to be negligible (Giddings et al. 1998).

Forest management practices and development of roads and human facilities may adversely affect lynx. However, the rarity and secretiveness of this species make its distribution and habitat requirements difficult to document (Ruediger 1994). The purpose of this report is to review and synthesize current literature on the effects of winter recreation on lynx within the Greater Yellowstone Area (GYA).

THE ABUNDANCE AND DISTRIBUTION OF LYNX IN YELLOWSTONE NATIONAL PARK

Although reliable information concerning the abundance and distribution of lynx is lacking, historical information suggests that this species was present but uncommon in Yellowstone National Park (YNP) from 1880 to 1980. This condition also describes the status of lynx in YNP today. Lynx were listed among animals that were present and seen by naturalists as early as the 1870s (Grinnell 1876, Blackburn 1879). Consolo Murphy and Meagher (In Press) documented the presence and distribution of lynx in YNP from 1893 to 1995 using sighting records, photographic records, and museum collections. They located 1 museum specimen of a female lynx, 34 sighting reports (39 total lynx), 17 observations of tracks, and 6 other forms of supportive evidence (*e.g.*, photographs). Lynx or their sign were observed parkwide, but visual observations were more common in the southern half of the park and tracks were more common in the north. Most (*n*=50) sightings and records of tracks occurred after 1930. Consolo Murphy and Meagher (In Press) included a reference to a hide from an illegally trapped lynx that was confiscated by park rangers near Norris Geyser Basin (Harris 1887). In addition to these records, 1 lynx was reported seen and 6 sets of lynx tracks were found in 1887 by T. Hofer, a pioneering naturalist and early visitor to the park (see *Field and Stream* 1887, April 7 to May 5 issues). Hofer's observations occurred at Norris Geyser Basin (tracks), Lower and Midway Geyser basins (tracks), Shoshone Lake (sighting), Alum Creek (tracks), and Canyon (tracks). *Yellowstone Nature Notes*, an in-house periodical of natural history observations made by YNP personnel, also contains 5 records of direct observations of lynx (7 total animals) spanning 1928 to 1958 that were not reported by Consolo Murphy and Meagher. More recently, Halfpenny (unpublished data) identified 1 set of lynx tracks near Snake Hot Springs in February 1979. From 1995 to present, 5 sightings of lynx were reported in YNP, 3 on the northern range and 2 in the park interior (K. A. Gunther, Yellowstone National Park, personal communication).

Unfortunately, records of lynx sightings or their tracks carry caveats with regard to reliability. YNP records prior to 1980 typically contained insufficient information to determine observer credibility and to estimate weather and lighting conditions. Consequently, misidentified animals may be represented in the data. In particular, inexperienced observers may easily confuse bobcats (*Lynx rufus*) with lynx.

Numerous researchers have attempted to document the presence of rare carnivores in YNP during this decade. Murphy (unpublished data) found no lynx sign while searching 7,500 km of transect on the northern winter range and vicinity from the winters 1987–88 to 1991–92 incident to cougar studies. No lynx were detected by Harter et al. (1993), who deployed 11 hair snares (387 trap nights) and 21 remote cameras (102 nights), and searched 16 track transects (116 km) on the northern winter range and vicinity from January to March 1993. Similarly, no lynx were found by Gehman et al. (1994), who deployed 20 hair snares (1,609 nights), 12 cameras (961 nights), and 31 track transects (200 km) from December 1993 to February 1994 on the northern winter range and vicinity. Finally, Gehman and Robinson (1998) did not detect lynx when they deployed 4 cameras (4 sites; approx. 138 nights) and 14 transects (80 total km) along the upper Gallatin River in YNP (see below for their sighting of a probable lynx track 10 km northwest of YNP).

THE PRESENCE AND DISTRIBUTION OF LYNX IN THE GYA

Museum, trapping, and other agency records indicate lynx distribution in the GYA prior to 1976 (Giddings et al. 1998; Fig. 1) with approximately 107, 6, and 8 occurrences of lynx in Wyoming, Montana, and Idaho, respectively (our counts from Giddings et al. 1998), including 8 records for Grand Teton National Park (GTNP). These records do not include a lynx killed in 1920 by ranger and his hounds in the Hellroaring Creek drainage (Stevenson 1920). In the GYA from 1976 to 1993, there are 122, 19, and 13 occurrences of lynx in Wyoming, Montana, and Idaho, respectively, including four records in GTNP. Lynx reports occur for the Absaroka, Beartooth, Centennial, Gallatin, Gros Ventre, Madison, Teton, Wind River, and Wyoming mountain ranges as well as forested portions of eastern Idaho (Giddings et al. 1998).

Laurion and Oakleaf (1998) surveyed 2,055 km of roads and 2,400 km of backcountry trails in 12 areas on the Shoshone (SNF) and Bridger–Teton (BTNF) national forests in western Wyoming during winter 1997–98. Lynx tracks were identified in three locales (four total track observations) on the SNF and one locale (two track observations) on the BTNF. In addition, D. Stevenson (1997) surveyed nine snow-covered transects 29 times (269 total km) near Bridger Lake, BTNF, from February to March 1997, but found no lynx sign. S. Patlas (Wyoming Game and Fish Department, personal communication) surveyed a total of 169 km of transect at nine locales in northern GTNP and vicinity but found no sign of lynx. However, citizen observers have recently seen lynx or their tracks near Big Piney, Kemmerer, Moose, and Dubois, in the Upper Greys River watershed, Wyoming (Laurion and Oakleaf 1998).

An adult male and a female lynx were captured in the Wyoming Range near Merna, Wyoming in 1996–97 as part of a research project being conducted by Wyoming Game and Fish Department (see Laurion and Oakleaf 1998). A total of five to seven lynx resided on the study area, including the radio-marked individuals. The radio-marked female produced four kittens during May 1998.

In Montana, Gehman and Robinson (1998) surveyed 12 snow-covered transects 39 times (170 total km) and deployed cameras at 15 different sites in the Gallatin National Forest in 1997–98. They identified a probable lynx track in Buck Creek, a tributary of the Gallatin River.

LIFE HISTORY

The breeding season for lynx spans March to May. Kittens are born in May or June after a 60- to 74-day gestation period. Young are born without teeth, but with closed eyes, folded ears, and a well-developed pelage. Lynx walk by age 24–30 days and are weaned at 3–6 months. However, kittens may consume meat as part of their diet by an age of 30 days. Kittens typically remain with their mothers until about age ten months, but the period of maternal care may extend into the next mating season. Females can breed at age ten months, but usually do not until 22 months.

Natural predators of lynx include coyotes *(Canis latrans)*, wolves *(Canis lupis)* (Banfield 1974), cougars *(Felis concolor)* (Koehler et al. 1979), wolverines *(Gulo gulo)*, and lynx themselves (Elsey 1954). Lynx contract rabies and distemper, but these diseases do not significantly affect their population dynamics. Dominant mortality factors are malnutrition and starvation of kittens (Brainerd 1985). Malnutrition may dispose lynx to disease and parasites (Quinn and Parker 1987).

SOCIAL ORGANIZATION AND SPACING PATTERNS

Lynx are solitary carnivores, remaining apart except when mating. Mothers support their altricial young without direct support of fathers. Spatial and temporal separation results from social intolerance and mutual avoidance that is accomplished through scent marking. Intersexual overlap for territories is high. During lows in hare numbers, adults of the same sex are mutually hostile, maintaining exclusive territories (Berrie 1973, Mech 1980). In a Washington study, strong territoriality may have resulted from a varied and relatively stable prey base (Koehler 1990a). As hare populations increase, social intolerance among lynx breaks down, prompting increases in the degree of range overlap (Slough and Mowat 1996). When hares are extremely scarce, lynx may become nomadic or emigrate.

Home range sizes differ by sex, prey density, and other factors. Females typically have home ranges that are smaller than males, varying from 10–243 km^2, but normally 15–20 km^2 in size. Home ranges varied from 36–122 km^2 for males in Montana (Koehler et al. 1979, Brainerd 1985). In Wyoming, a male's range was 131 km^2 and a female's was 137 km^2

(Laurion and Oakleaf 1998). In Alaska and Canada, home ranges may exceed 40–80 km^2 when hare populations decrease. Large ranges may indicate prey scarcity (Hatler 1988). Inverse relationships between hare numbers and the size of lynx ranges are documented (Brand et al. 1976, Ward and Krebs 1985, Poole 1993). Home ranges may be abandoned at a threshold of low hare densities, prompting lynx to turn nomadic (Ward 1985, Ward and Krebs 1985). The relatively large sizes of lynx home ranges in the Rocky Mountains suggests that the availability of snowshoe hares is low.

Lynx typically achieve densities of one per 15–25 km^2. In Washington, density was one per 40 km^2 (Koehler 1990a). Home range sizes and densities of lynx exhibit regional and local variation that depend on topography and food availability. When hare populations are low, lynx may concentrate in pockets of high hare density, leading to density estimates that are not representative for landscapes at a broad scale (Koehler and Aubrey 1994).

POPULATION DYNAMICS

Lynx generally occur at low density and are associated with boreal forest habitats. Their population dynamics are characterized by low reproductive rates and are strongly related to population dynamics of snowshoe hare, a keystone species that is the primary prey of lynx. In Canada, lynx populations fluctuate roughly on a ten-year cycle, lagging behind a similar cycle for snowshoe hares (Elton and Nicholson 1942, Keith 1963). While hare densities may change 200-fold, those of lynx change only up to 20-fold. One explanation is that lynx numbers are tied to a poorly understood interaction between hares and vegetation, with regional synchrony tied to weather effects.

Cycles may be muted or absent near the southern limits of the lynx's distribution (*i.e.*, in the conterminous U.S.), where hare populations apparently are more stable than those in Canada (Dolbeer and Clark 1975), possibly owing to greater diversity and stability in hare predators and competitors and the absence of adequate habitat during periods of hare lows. Snow-tracking surveys for hares in Montana showed a three-fold change in numbers of hare tracks from 1990 to 1998; lynx tracks varied eight-fold (Giddings et al. 1998). Consequently, dramatic differences in reproduction, habitat use, prey selection, dispersal, and vulnerability may exist between lynx populations in Canada and the conterminous U.S.

When hare populations crash, lynx may emigrate great distances, potentially making treks from Canada to the GYA. Dramatic increases in lynx numbers occurred in western Montana following peaks in the Canadian population during 1962–63 and 1971–72 (Hoffmann et al. 1969, Koehler and Aubrey 1994). Following the hare crash of the early 1970s, lynx populations apparently increased in Wyoming as suggested by the high trapper harvest in the Wyoming Range (Laurion and Oakleaf 1998). Immigrating lynx have large home ranges and little reproductive success. When hares are scarce, lynx may also concentrate in small areas making them vulnerable to human-caused mortality (Koehler and Aubrey 1994). Consequently, rapid declines in populations occur. For example, Minnesota trappers harvested 215 lynx in 1972, 691 in 1973, 88 in 1974, and 0 in 1975 (Mech 1980). Recovery from trapping exploitation may be slow when lynx are at low numbers (Laurion and Oakleaf 1998).

Lynx are characterized by fluctuating reproductive rates that are driven by food limitation. Females may not reproduce at all during food shortages. In Montana, pregnancy rates of adult females reached 90 percent, but declined to 33 percent when food was scarce (Giddings 1994). Litters of adult females averaged 3.2 kittens and those of yearlings averaged 1.7 (Brainerd 1985) or 2.7 (Giddings 1994). In the GYA, one female had four kittens (Laurion and Oakleaf 1998). In general, population dynamics of lynx are affected more by failure to produce litters than the size of litters.

Food availability directly correlates with the survival of young lynx. Few kittens survive when food is scarce, with the result that recruitment of offspring to the breeding population is low to non-existent (Koehler 1990a). In the Wyoming Range, Laurion and Oakleaf (1998) found that few kittens survived through the summer.

Lynx may disperse long distances from their natal area. Dispersal distances for females range from 103–250 km and from 164–1,100 km for males (Slough and Mowat 1996). One female from Montana moved 325 km to British Columbia (Brainerd 1985). Previously territorial adults may become transient if prey bases become reduced. Most dispersers are young animals in search of unoccupied territories.

FOOD HABITS

Snowshoe hares constitute the main portion of the lynx's diet, about 60 percent in winter and 40 percent in summer. Other prey include squirrels (*Tamiasciurus hudsonicus*), voles (*Clethrionomys* spp. and *Microtus* spp.), mice (*Peromyscus* spp.), grouse (*Bonasa* spp. and *Dendragapus* spp.), ptarmigan *(Lagopus* spp.), and other birds. While not important predators of ungulates, lynx occasionally may kill adult deer (*Odocoileus* spp.) and moose (*Alces alces*) in poor physical condition or when snow conditions are favorable for predation or when ungulate offspring are available. Although chiefly an obligate predator, lynx will scavenge carcasses and eat vegetation.

Lynx take a variety of mammals when hares are scarce, but only hares support high population densities of lynx (Koehler 1990b). Kill rates average about two hares per three days, but rates vary with prey density. Food consumption may be 37 percent lower when hares are scarce (Brand et al. 1976). Food caching has been reported, particularly when prey is scarce.

HABITAT REQUIREMENTS

In Wyoming, lynx occur primarily in spruce-fir and lodgepole pine forests that slope at 8–12° at elevations between 2,437 and 2,937 m. For denning, lynx often select mature stands (250 years or older) of Engelmann spruce (*Picea engelmanni*), subalpine fir (*Abies bifolia*), and lodgepole pine (*Pinus contorta*) on north or northeast slopes and prefer sites larger than 30 acres in size with more than 80 downed logs (>20 inches diam.) per acre on north or east aspects. Old-growth spruce forests that have escaped natural fires in landscapes that are otherwise dominated by lodgepole pine also provide ideal denning habitat. Denning habitat is enhanced if forest parcels contain numerous alternate den sites and/or they are connected to other denning habitats (Koehler and Aubrey 1994, Tanimoto 1998). Dens are often located in hollow logs or in brush piles, particularly where surrounded by dense thickets. Downed logs 40–50 m in length provide escape cover for young kittens (Koehler 1990a, Koehler and Brittell 1990). Security cover is also necessary for diurnal rest areas used by adults and kittens that no longer use dens. Diurnal bed sites frequently occur in thickets near game trails.

Lynx are specialized predators that hunt in habitats preferred by snowshoe hares. Hares require densely stocked stands of deciduous shrubs or young conifers (*e.g.*, lodgepole pine

<2.5 cm dbh) (Koehler and Brittel 1990) for forage, escapes routes, and thermal cover. Hare abundance is positively correlated with the density of cover at 1–3 m above ground or snow. Hare food is typically woody browse smaller than 4 mm in diameter that is less than 60 cm above the ground or snow. Stands that reach densities of 16,000 stems per ha are ideal (Keith et al. 1984). The structural attributes of vegetation needed by hares can be achieved in less than 20 years of growth and serial succession in the moist forests of Oregon and Washington. However, these conditions may not be achieved for 80 years or longer in the GYA.

Hares require a diversity of food items, foraging on birch (*Betula* sp.), poplar (*Populus* sp.), willow (*Salix* sp.), and conifers. Pines are preferred to spruce, and spruce is preferred to fir. Because the nutrient content and palatability of forage decreases with increasing stem diameter, hares must browse selectively, consuming about 300 g per day, and cannot compensate for low food quality by increasing their consumption. Aspen (*P. tremuloides*) stands and forest edges, as well as open grass meadows and edges with forests, may also support high numbers of hares and lynx. At the southern extent of lynx range, Colorado lynx were found near upper treeline in mature spruce-fir habitats where the forest and tundra edges provided food for hares (Halfpenny and Miller 1981; Halfpenny and Thompson 1987; Thompson and Halfpenny 1989, 1991).

Hares feed on buds, young branches, and tips of older trees. Forage must be above the snow (hares do not excavate), but not out of reach. Heavy snowfall may bend small trees, increasing forage for hares (Koehler et al. 1979, Koehler 1990b, Koehler and Brittell 1990). Deer, elk, and moose often reduce browse available to hares at ground level, particularly where wintering ungulates concentrate in or near habitats used by hares (Olson 1957; Telfer 1972, 1974).

Lynx denning and hunting habitat must be connected by corridors providing cover for travel. Corridors used by lynx include tops of ridges and riparian zones with more than 30 percent canopy cover provided by subalpine fir, spruce, and lodgepole pine. Corridors should be at least 100 m in width and contain at least 300 stems per acre (Ruediger 1994). Lynx will cross narrower openings but will rarely hunt in them.

On a landscape scale, lynx habitat includes a mosaic of early seral stages that support snowshoe hare populations and late seral stages of dense old growth forest that is not heavily fragmented by logging, roads, reservoirs, train tracks, or other developments. Connectivity between lynx populations is critical. Dispersal corridors should be several miles wide with only narrow gaps. Large tracts of continuous coniferous forest are the most desirable for lynx travel and dispersal (Tanimoto 1998).

INTERSPECIFIC INTERACTIONS

Lynx may compete with canids, other felids, mustelids, and raptors for snowshoe hares and small mammals. Bobcat home ranges often exhibit elevational separation from those of lynx, which are better adapted to deep snow. Bobcats are thought to displace lynx where both felids are locally sympatric. However, lynx occasionally may kill bobcats (Giddings et al. 1998).

EFFECTS OF WINTER RECREATION ON LYNX

Winter recreation has cultural, economic, and social aspects that may affect lynx both directly and indirectly. With respect to winter recreation, direct effects are those that change the survival of individuals. Losses resulting from lynx trapping, non-target trapping, or accidental deaths (*e.g.*, hit by cars) are examples of direct effects. Losses or degradation of habitat through habitat destruction or disturbance are examples of indirect effects. Because both direct and indirect effects influence vital rates (*e.g.*, natality and survival), they may strongly influence the viability of lynx populations.

Because of the secretive nature of lynx and their habit of using deep-forest habitats, few ecological studies of lynx exist, let alone research on the effects of winter recreation. However, the paucity of data should not be construed as evidence that winter recreation has no adverse effects on this species.

DIRECT EFFECTS

Trapping seasons may significantly reduce the viability of lynx populations, particularly if lynx are few and/or key breeding individuals are removed. Currently, Montana is the only state in which lynx may be legally trapped, but very few are taken in the Montana portion of the GYA. In all states of the Yellowstone ecosystem, lynx may also be killed incidentally by bobcat trappers and hunters that are unable to distinguish the two felids when observed directly (Todd 1985, Bailey et al. 1986, Koehler and Aubrey 1994, Giddings et al. 1998). In addition, houndsmen may chase lynx with their dogs after mistaking lynx tracks for those of bobcats or cougar.

Roads and snowmobile trails are an important aspect of winter recreation because they provide people with their principal access to wildlands. The type, density, and distribution of roads and trails in lynx habitat affect the probability that trappers will locate lynx tracks and legally take them in traps. Roads also affect the rate at which lynx are killed, incidentally by trappers and/or illegally by hunters or houndsmen. Thompson (1987) noted that all known lynx sightings on Vail Mountain Ski Area, Colorado, were animals that were shot (*n*=1) or illegally trapped (*n*=2). Easy access to lynx habitat is particularly detrimental when pelt prices are high or recruitment of young lynx to the breeding population is low (Koehler and Aubrey 1994).

No road-killed lynx have been documented in the GYA, but losses of coyotes, wolves, cougars, and black and grizzly bears are well documented (Caslick and Caslick 1997, Gunther et al. 1998). During an attempted restoration of lynx in New York, 22 percent of introduced animals were killed by automobiles (Brocke et al. 1992, Weaver 1993).

Lynx behavior may predispose them to collisions with vehicles, especially when emigrating, hunting, or travelling (Weaver 1993). Road edges and train tracks support exposed forbs, grasses, and shrubs during winter; these locations are suited to foraging snowshoe hares, mice, voles, and other small mammals. Consequently, these sites are also excellent hunting areas for lynx (Koehler and Aubrey 1994). During winter, lynx frequently travel along roads where adequate cover is available on both shoulders (Koehler and Aubrey 1994).

INDIRECT EFFECTS

Humans alter the structure, biotic composition, and arrangement of habitat components that are essential to lynx. Winter recreation and its associated infrastructure reduces the amount of suitable habitat available to lynx and reduces the effectiveness of pristine habitat because human disturbance causes lynx to avoid habitats that are otherwise suitable.

Habitat Destruction.—Development of resort and other destination infrastructure for winter recreationists destroys and fragments lynx habitat. Human populations in the ten counties comprising the GYE increased 7.4 percent from 1980 to 1990, while the number of households increased 8.4 percent (Feigley 1993). Although only a fraction of this development occurred in habitats potentially used by lynx, road and housing development in expanding recreation-based communities such as West Yellowstone and Big Sky, Montana, and Old Faithful, Wyoming, could represent a significant cumulative loss of lynx habitat. In addition, the highways and improved roads that connect these communities also represent habitat losses because the improved surface, particularly for wide roads (>15 m), is essentially unusable by lynx except for aforementioned opportunities to travel or hunt along the road shoulder.

Loss of Habitat Effectiveness Resulting From Disturbance.—Human disturbance associated with recreational infrastructure and roads can reduce the effectiveness of habitat in supporting lynx, even if habitat is otherwise of high quality. Losses of habitat effectiveness can be adverse because disturbances preclude lynx from using habitat in an optimal manner. Lynx and other wildlife may avoid developments and roads because of the association with humans, particularly if they are unfamiliar with the sights, sounds, and smells that accompany human activity (Gutzwiller 1995).

The paucity of studies makes it difficult to assess the magnitude of disturbance and displacement associated with winter recreation. Year-round, ungulates that are not habituated to humans adjust their distribution and activity patterns to avoid human activity (Lyon 1979, Aune 1981, Rost and Bailey 1979, Edge et al. 1985, Kufeld et al. 1988, Cassirer et al. 1992, Caslick and Caslick 1997). Displacement, including den abandonment, is documented for black bears (*Ursus americanus*) and grizzly bears (*U. arctos*) (Jonkel 1980, Goodrich and Berger 1994).

The search for cross-country and downhill skiing opportunities leads recreational skiers to prime lynx habitat. Downhill and cross-country ski development destroys and fragments lynx habitat and increases disturbance associated with human traffic, thereby reducing habitat security for lynx (Halfpenny and Miller 1981; Thompson 1987; Halfpenny and Thompson 1987; Thompson and Halfpenny 1989, 1991; Halfpenny 1991). Development of winter ski areas may also increase disturbance of lynx in the off-season, as recreational use and maintenance activity will occur year-round.

Snowmobiling may be particularly adverse to lynx because: (1) this activity occurs when animals are frequently in poor condition due to the stresses of winter (Anderson 1995); (2) this activity may be dispersed on the landscape (*i.e.*, not confined to roads) on national forest lands outside of wilderness areas; (3) it may occur at night when lynx are usually active; (4) it is frequently accompanied by human disturbance and habitat loss associated with recreational infrastructure; and (5) this activity may alter the density and distribution of snowshoe hares, a favored prey item. In Ontario, Canada, snowmobile activity altered the mobility, distribution, and movements of hares (Neuman and Merriam 1972). Road plowing, grooming, and construction activities that support snowmobilers may also significantly reduce the effectiveness of winter lynx habitats. In this regard, road density and the level of automobile use are important considerations because they affect the frequency and intensity of disturbance.

Disturbance, however, does not necessarily lead to a continued reduction in habitat effectiveness for lynx. With repeated exposure to human activity that is predictable in time and space, lynx may adapt behaviorally or physiologically (Bowles 1995). Lynx visited Geneva Basin and Vail Ski areas in Colorado at night to scavenge at garbage dumps (Halfpenny et al. 1982; Thompson 1987; Thompson and Halfpenny 1989, 1991). Lynx also used ski runs at Vail from adjacent non-developed habitat, despite night grooming operations (Thompson and Halfpenny 1989, 1991). Lynx also visited a night-active winter construction camp on the Frying Pan River in Colorado, presumably scrounging for garbage (J. Halfpenny, unpublished data).

Non-motorized recreational activities, such as backcountry cross-country skiing or snowshoeing, may affect lynx, particularly because the disturbance associated with these activities is often dispersed and unpredictable to mammals. Surprisingly, disturbance by people may have a greater negative effect than motorized vehicles on established roadways because mammals habituate more quickly to mechanical noise than to noises of humans (Schultz and Bailey 1978, Aune 1981, Cassirer et al. 1992, Gabrielsen and Smith 1995). Laughing and yelling can arouse responses of mammals at greater distances than snowmobile noise (Bowles 1995).

The cumulative impacts of dispersed winter recreation must also be considered. For example, the adverse effects of motorized recreation in one habitat may be additive to adverse effects of housing infrastructure elsewhere in an ecosystem. Consequently, the potential effects of all recreational activity should be considered together in cases where a single lynx population or a lynx metapopulation is present. In Colorado, the development of three potential ski areas (Wolf Creek Pass, Wolf Creek, and East Fork of the San Juan) in lynx habitat could have resulted in habitat destruction and alteration at each site, as well as reduced habitat suitability within the triangle among ski areas because of increased access and habitat size reduction (Halfpenny 1991).

One other relationship between winter recreation and lynx deserves consideration: the cumulative effect of human activity on the survival of lynx and their population viability during periods when hare populations are low. Stresses associated with winter recreation might force lynx across a mortality or reproductive threshold, leading to population declines and extirpation of local populations. As previously mentioned, female lynx fail to produce litters or have reduced litter sizes during periods of food limitation. Kittens may also frequently die of malnutrition during winter due to the stresses incurred during this season. Thus, reduced recruitment of breeding individuals during periods of hare shortages contributes directly to dramatic declines in lynx populations. Disturbance of wintering lynx may cause them to expend energy beyond their caloric intake, decreasing natality and increasing mortality. When a disturbance occurs over a large area, Anderson (1995) suggests animal populations could be extirpated in a single winter. Thereafter, food limitation and human disturbance may delay successful recolonization of the area.

MANAGEMENT GUIDELINES

Lynx are very specialized carnivores, requiring snowshoe hares as part of their diet and mature conifer-fir forests for denning. Because of these requirements, lynx are potentially affected by snow-based recreational activities that occur in cold forest habitats. Winter recreation at Potential Opportunity Areas in the GYA may affect lynx as described below.

(1) Destination areas. Human activity at destination areas has the potential to affect lynx, as this species both uses and avoids habitats near human facilities (Halfpenny et al. 1982). Displacement of lynx from winter habitat is an important management concern. Use of ski areas, other resorts, and communities is increasing in the GYA. New developments, or significant increases in existing developments, destroy at least some

lynx habitat and may cause lynx to increase avoidance of habitats that are immediately peripheral to these sites. Downhill ski areas should be designed to reduce impacts on lynx by reducing habitat fragmentation and providing security zones between activity locations (Thompson 1987). Lynx may also habituate to human foods, potentially increasing management problems and lynx mortality. Proper garbage and food storage would reduce unnatural attractants and management actions.

(2) Primary transportation routes and (3) scenic driving routes. Roads, whether they are maintained or unmaintained, provide recreational access. Increased demand for winter recreation may be a catalyst for creating new roads. Roads may increase lynx mortality due to trapping pressure and collisions with vehicles. The road density and traffic volume may indirectly influence levels of lynx mortality. Disturbance associated with automobiles, snowmobiles, and recreationists may pose a risk to denning lynx. More roads may ultimately reduce habitat effectiveness for lynx and increase habitat fragmentation.

(4) Groomed motorized routes. Snowmobile traffic may reduce the effectiveness of lynx habitats that are peripheral to groomed snowmobile routes. Lynx and hares that use habitats in the vicinity of roads may be adversely stressed by disturbance. Night use of roads may be more detrimental than day use because lynx are nocturnal and crepuscular. However, lynx may show some habituation to snowmobile activity where it is temporally and spatially consistent. Restrictions on quantity and timing of snowmobile travel could reduce adverse effects on lynx.

(6) Backcountry motorized areas. Snowmobiles are frequently used in the backcountry at high elevations, often within or near lynx habitat. Because this activity is highly obtrusive and usually dispersed on the landscape, it has a strong potential to displace lynx from their winter haunts, increase stress levels, and reduce the fitness and viability of lynx populations (Cole and Landres 1995).

(7) Groomed nonmotorized routes. Skiing on groomed routes may affect lynx when the activity occurs at high levels. Therefore, skiers should be directed away from high-quality lynx habitat, particularly where lynx are already known to exist.

(8) Nonmotorized routes. Skiing and snowshoeing along ungroomed routes could affect lynx where people use trails frequently. Typically, lynx will not be frequently disturbed by these activities because use of ungroomed trails in the GYA, particularly in deep-forest habitats, is still relatively uncommon. However, forest managers may need to restrict access to prime lynx habitat.

(9) Backcountry nonmotorized areas. Dispersed activities such as backcountry skiing, snowshoeing, and camping have the potential to disturb lynx, but these activities may not be adverse because they occur at low levels in the GYA.

NEEDS FOR MANAGEMENT-RELATED MONITORING AND RESEARCH

Managers should develop a GIS-based inventory of snowshoe hare and lynx habitat. Aerial mapping efforts should be supplemented with ground-based work that includes density estimates of snowshoe hare derived from track surveys and pellet counts. The effects of winter recreation and associated off-season activities should be assessed in the context of cumulative effects at scales applicable to lynx populations and landscapes.

Existing knowledge on the distribution, abundance, demography, and habitat requirements is grossly inadequate to conserve lynx populations. A detection and monitoring system for lynx should be developed using ground-based track surveys (*e.g.*, Halfpenny et al. 1995) or cheek-rub carpet patches (J. Weaver, personal communication; Turbak 1998). Surveys should be repeated systematically over time to detect short-term and long-term changes in the distribution and abundance of lynx.

The rarity of lynx in the GYA dictates a conservative approach to managing lynx and their habitat. Maintaining corridors for possible lynx (and other wildlife) migration from northern Montana or Canada would facilitate conservation of this species.

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EFFECTS OF WINTER RECREATION ON MID-SIZED CARNIVORES (WOLVERINE, FISHER, MARTEN, LYNX, BOBCAT, RED FOX, AND WEASEL)

POPULATION STATUS AND TREND

Wolverines (*Gulo gulo*) are considered scarce or rare in the Greater Yellowstone Area (GYA). The GYA probably has a small population, but the actual status and range remain uncertain (Clark et al. 1989). Although the U.S. Fish and Wildlife Service has concerns about their population status as well as threats to their long-term viability, the wolverine has not been listed under the Endangered Species Act. The wolverine has been classified as a protected species in Idaho since 1965. It is a species of special concern in both Idaho (native species that are either low in numbers, limited in distribution, or have suffered significant habitat loss) and Montana (species highlighted for data acquisition and subsequent management efforts) and a Priority 3 species in Wyoming (knowledge of this species is so limited that it cannot be adequately evaluated). The wolverine is listed as a sensitive species by Region 4 (Intermountain Region) of the U.S. Forest Service and as sensitive in Idaho by Region 1 (Northern Region) (species for which population viability is a concern) (Clark et al. 1989).

Fishers (*Martes pennanti*) may exist in very low numbers within the portion of the GYA that includes the northern half of Wyoming, but they have been extirpated from the Montana portions of the GYA, and they were never known to occur in the Idaho portion of the GYA (Clark et al. 1989). The fisher is a species of special concern in Idaho and Montana and a Priority 3 species in Wyoming. Region 4 of the U.S. Forest Service lists it as a sensitive species (Clark et al. 1989).

Martens (*Martes americana*) are classified as “indicator species” on the Beaverhead, Bridger–Teton, Shoshone, and Gallatin national forests in the GYA. With appropriate management, the marten can be assured a healthy role in the GYA (Clark et al. 1989).

Specific information on the status and distribution of lynx (*Felis lynx*) in the GYA is not available. It is possible that the few reported sightings are of transient animals, but is more probable that a small population persists in the GYA (Clark et al. 1989). The lynx has been proposed for listing under the Endangered Species Act. The lynx is a species of special concern in Idaho and Montana and a Priority 3 species in Wyoming (Clark et al. 1989). Region 4 of the U.S. Forest Service lists it as a sensitive species.

The bobcat (*Felis rufus*) and red fox (*Vulpes vulpes*) are managed as furbearers in all three states and may be hunted or trapped during the furbearer season. Populations are considered stable.

The weasel (*Mustela frenata*) is an unprotected species, and little is known about its status.

LIFE HISTORY

WOLVERINE

Wolverines remain active throughout the year, even during the most severe winter weather. They inhabit the coniferous forest zone, generally at higher elevations during the summer and mid- to lower elevations during winter. Lower elevation riparian areas may be important winter habitat. Wolverines generally avoid large parks, meadows, and clearcuts. Wolverines prefer to hunt around small meadows, timbered thickets, cliffs, riparian areas, and ecotonal areas (Clark et al. 1989, USFS 1991).

Females den in late February to early March. The female may move the kits several times prior to weaning, which occurs when kits are 9–10 weeks old. The offspring normally remain near their natal area at reproductive maturation, establishing their home range near that of their mother (Copeland 1996).

Idaho wolverines denned in high-elevation, subalpine cirque basins, locating the den beneath the snow in the tunnels and chambers associated with big boulder talus. Boulder caves beneath deep snow likely provide a stable thermal environment for the protection and rearing of kits. High-elevation subalpine habitat provides seclusion and reduces vulnerability to kit predation prior to weaning. Northeasterly aspects and glacial cirques provide persistent snow coverage and den stability until the mid-May weaning period (Copeland 1996).

FISHER

Fishers prefer extensive, continuous forest canopies such as those found in dense, lowland forests or mature to old-growth spruce-fir forests with high canopy closure. They remain active throughout the year. They appear to be restricted to areas with relatively low snow accumulations, and they travel along snowshoe hare trails or their own previously made trails when snow is deep and fluffy. They avoid open areas such as meadows, grasslands, and clearcuts, and they may be limited by snow depth. Brush piles and large diameter trees, snags, and hollow logs provide critical denning sites in winter. Females usually give birth in tree dens located in high cavities of large trees. The breeding period is March through April (Clark et al. 1989, USFS 1991, Ruggiero et al. 1994, Heinemeyer and Jones 1994).

MARTEN

Martens remain active throughout the year. They use a variety of forest types, but they are most active in older stands of spruce-fir. In the central Rockies, they are most often associated with old-growth forests in winter. They engage in more aboreal and subnivean activity than other carnivores. They forage on mice and voles, and, as the snow deepens, they switch to pine squirrels and hares. They use meadows, forest edges, and rock alpine areas. The young are born mid-March to late April. The young are reared in dens, and the mother moves the young among dens. The dens are important to recruitment and may represent a special habitat need (Clark et al. 1989, Ruggiero et al. 1994).

LYNX

Lynx are generally found in the northern boreal forest in association with snowshoe hare habitat. Early successional forests with high densities of shrubs and seedlings are optimal habitat for hares and, consequently, important for lynx as snowshoe hares are the major food of the lynx. Hares normally make up 80 percent of the lynx diet, even more when snowshoe hare density is high. Lynx prefer dense lodgepole pine forests for hunting snowshoe hares and higher elevation spruce-fir forests for denning. Mature forest stands are used for denning and cover for kittens as well as for travel corridors. Breeding occurs from mid-March to early April. During this time females seek out males by moving into male territories (Clark et al. 1989, USFS 1991).

BOBCAT, RED FOX, AND WEASEL

This group of carnivores remains active throughout the year. Bobcats use a wide variety of habitats. They need cover to stalk prey and avoid large open areas. Red foxes are also found in a variety of habitats, from heavily forested areas to open meadows and brushy lowlands. Red foxes mate in late winter and den in crevices, caves, or burrows. Long-tailed weasels are extremely solitary (except during the mating period) and are voracious hunters. Weasels often tunnel beneath the snow following prey when hunting during winter (Fitzgerald 1977).

HUMAN ACTIVITIES

Winter recreational activities such as snowmobiling, cross-country skiing, backcountry skiing, and snowshoeing have the potential to affect wolverine, fisher, marten, lynx, bobcat, red fox, and weasel. These mid-sized carnivores have certain biological traits that suggest vulnerability to human uses (in this case, recreational activities) specifically during the stressful winter period. These include low population densities, low reproductive rates, large home range sizes, secretive behavior, and avoidance of humans. The home range sizes of some of the mid-sized carnivores require that they regularly cross snowmobile and cross-country ski trails.

Carnivore foraging behavior in forested areas may be disrupted along groomed trails and other travel corridors. Displacement or avoidance may occur due to noise of snowmachines or to human presence. Snowmobile trails may facilitate travel for some carnivores, but compaction of snow due to grooming or from snowmobile use off existing roads or trails may adversely affect the subnivean habitat of prey species and, therefore, impact foraging opportunities for carnivores.

Existing marked and groomed snowmobile trails and the expansion of these trail systems into new areas facilitates trapping of furbearers and may increase the accidental take of non-target carnivores.

POTENTIAL EFFECTS

Forest fragmentation as a result of timber harvest is a significant source of habitat loss specifically for the fisher, marten, and lynx (Clark et al. 1989, USFS 1991, Ruggiero et al. 1994). Habitat loss could also result from clearing routes for groomed snowmobile and cross-country ski trails. However, routes in the GYA are generally along existing roads and trails, which were developed and are used for summer travel. Dispersed winter activities typically occur within non-forested areas that require no clearing.

Trapping is the most direct way that humans affect carnivore populations, and it can be a significant source of mortality. Overtrapping and accidental trapping of non-target species are considered threats to this group of animals. Highway accidents are another direct human effect on carnivores (Clark et al. 1989, USFS 1991, Ruggiero et al. 1994).

Mortality resulting from an accidental collision with a snowmobile is possible, but the probability is low. Intentional killing of carnivores by a snowmobiler is possible, but most likely it would only occur in rare, isolated incidents.

Winter stress combined with human disturbance/harassment may cause increased mortality to wildlife. Most studies on this topic have been conducted on ungulates, however. Copeland (1996) found that human activities near wolverine dens during the denning and kit-rearing period may cause den abandonment and displace wolverines into suboptimal denning sites. This could result in lower reproductive success and/or kit survival.

Natal dens are also important to recruitment for other carnivores, including the fisher, marten, and lynx. Minimal human disturbance is an important feature when females choose a den site. Fisher and lynx are likely to move to another den if disturbed.

Snowmobile use has been shown to affect snowshoe hare (an important prey species for some carnivores, particularly the lynx) and red fox mobility (Schmid 1983).

Compaction of snowfields by snowmobiles alters the mild snow microenvironment, potentially affecting organisms that live within or beneath the snow by increasing temperature stress or restricting movement by compacting the air spaces between the snow and the ground (Schmid 1983, Boyle and Sampson 1985). Winter mortality of small mammals is markedly increased under areas compacted by snowmobiles. The reduction in population numbers of these small mammals could well reduce the population of species preying upon them (Bury 1978). Fitzgerald (1977) found that the long-tailed weasel often tunnels beneath the snow when hunting during the winter. Raine (1983) found that martens made less use of subnivean space when the snow surface was crusted, probably because of difficult access.

A significant effect on carnivores from winter recreational activities is displacement from or avoidance of high recreational use areas (*i.e.*, groomed trails, marked trails, destination areas, and play areas). Human use will increase where high recreational use areas exist or are provided. As the associated recreational use level increases, the impact on carnivores also increases (Ruediger 1996).

WOLVERINE

A study in Idaho found females sensitive to human activity near the maternal den. The subalpine cirque habitats selected by Idaho wolverines for denning are often preferred winter recreational sites for backcountry skiing and snowmobiling. If females are disturbed during the denning and kit-rearing periods, they may move kits to suboptimal den sites, which may decrease reproductive success and kit survival. In two cases, human disturbance near maternal dens resulted in den abandonment by females and kits (Copeland 1996).

Humans access on snowmobiles or all-terrain vehicles in winter and early spring could cause behavioral disturbances. This disturbance may impair kit survival if females use less secure den sites (Ruggiero et al. 1994).

Other studies found that winter recreational activities affect denning. Nursery dens were abandoned by female and kits upon discovery of human tracks. Human activity around dens in Finland and Norway resulted in den abandonment (Idaho Department of Fish and Game et al. 1995).

FISHER

Fishers appear to be tolerant of moderate degrees of human activity including low-density housing, farm roads, and small-scale logging (Heinemeyer and Jones 1994). In New Hampshire, the presence of human activity and domestic animals appeared to have little effect on fisher movement (Heinemeyer and Jones 1994). Fishers in Maine tolerate a marked degree of human activity (Heinemeyer and Jones 1994). In Idaho, fishers were commonly observed in close proximity to occupied residences. They rarely flushed from their roost sites when researchers approached within a few feet. Females with kits may be more sensitive to disturbance and may move their kits periodically to new dens (Heinemeyer and Jones 1994).

Other studies show that fishers generally are more common where densities of humans are low and human disturbance is reduced. They are secretive, usually avoid humans, and seldom linger when they become aware of the presence of humans. The females use one to three dens and are more likely to move if disturbed. Indirectly, human activities may lead to negative impacts on fishers through increased human access to fisher populations (USFS 1991, Ruggiero et al. 1994, Heinemeyer and Jones 1994).

LYNX

Human access into remote areas may have direct and indirect negative effects on lynx populations. During winter and summer, lynx travel along roadways, which may make them more vulnerable to human-caused mortality (Ruggiero et al. 1994). Lynx are believed to be susceptible to human-caused disturbances during the denning period, and it is believed that females will move kittens (thereby increasing the chance for mortality) in response to disturbance. Minimal human disturbance is an important feature of the den site (Ruggiero et al. 1994, Idaho Department of Fish and Game et al. 1995).

Lynx are specialized deep-snow predators, an adaptation that permits them to live year-round at high elevations, thereby minimizing competition during the physically stressful winter months. Snowmobile or cross-country ski trails allow lynx competitors to infiltrate high-elevation habitats during winter, thereby increasing competition for a limited food supply (Idaho Department of Fish and Game et al. 1995).

The mid-sized carnivores in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(2) Primary transportation routes
(3) Scenic driving routes
(4) Groomed motorized routes
(5) Motorized routes
(6) Backcountry motorized areas
(7) Groomed nonmotorized routes
(8) Nonmotorized routes
(9) Backcountry nonmotorized areas
(10) Downhill sliding (nonmotorized)
(12) Low-snow recreation areas

MANAGEMENT GUIDELINES

A literature search produced little information on how winter recreational activities impact carnivores; research on carnivores is extremely expensive and is mostly non-existent on mid-sized carnivores. Biologists, land managers, and recreation specialists will therefore need to practice “adaptive management” and “professional judgement” when developing winter use or recreational management plans until more information is available.

Existing winter trail systems/play areas and the development of new trails or designation of new play areas, particularly new areas, should be considered a negative impact on mid-sized carnivores. To avoid impacts, public land managers should exclude recreational activities from important areas that are used by carnivores during the winter.

Copeland (1996) recommends that management exclude human recreational activities within a five-mile buffer of predicted wolverine denning habitat from January 1 to May 31. Recreational activities outside the restricted time period should be managed for minimal intensity (*e.g.*, institute skier/snowmobile quotas and/or weekend closures).

Wolverines were specific in the sites they selected for natal and maternal dens in central Idaho. For example:

- Dens were situated above 8,000 feet in elevation. Although this elevational demarcation may vary throughout the wolverine’s regional distribution, it is likely applicable within the Targhee National Forest.
- Dens tended to be within a north-northeast aspect range (between compass readings greater than 320 degrees and less than 130 degrees).
- Dens selected had zero vegetative overstory (bare-exposed rock cover type).

- Den sites tended to be in the concave physiographic landscape feature of a glacial cirque.

Conserving wolverines may require large refugia connected by adequate travel corridors. Refugia provide core habitat for wolverine populations. Security areas must be available to provide undisturbed seclusion for reproducing females. Federal land-use regulations need to provide flexibility in administering backcountry winter recreational access and management (Ruggiero et al. 1994, Idaho Department of Fish and Game et al. 1995).

Providing protected areas within optimal habitat in the western mountains may be important to the persistence of lynx (Ruggiero et al. 1994). A strict, no-access management program is not recommended, but, rather, a proactive effort that involves community education and participation to protect lynx (Idaho Department of Fish and Game et al. 1995).

In many cases managers may have to use professional judgement combined with common sense to conserve the mid-sized carnivores. When conflicts occur between winter recreational activities and protection of carnivores, managers should err on the side of the carnivores. The winter period is a critical time for survival because of the extremely harsh weather conditions in the Greater Yellowstone Area.

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EFFECTS OF WINTER RECREATION ON MOOSE

The distribution of moose (*Alces alces*) corresponds to environments where snow is a dominant feature in the winter. Moose are anatomically and behaviorally suited for areas where winter conditions can be harsh. These are often the same areas where humans pursue winter recreational activities. Because of this, there is a strong potential for some types of winter recreation to affect moose.

POPULATION STATUS AND TREND

Moose may have been rare in western North America during historic as well as pre-Columbian times (Peterson 1955, Kelsall and Telfer 1974, Kay 1997). However, since about 1900 moose appear to have extended their range and/or become more numerous (Kelsall and Telfer 1974, Kay 1997).

Estimating moose population size has proven to be a consistent problem in many areas (Timmermann 1974, 1993; Gasaway et al. 1986), and a lack of accurate estimates has hampered good management (Gasaway et al. 1986). Some attempts to determine moose population status and trend in the Greater Yellowstone Area (GYA) have been equally problematic (Tyers unpublished data, Gasaway 1997), and a good count for this region has not been achieved. Although demographic data are not available at a large landscape level, it is known that moose are uncommon compared to other ungulates in the GYA. In addition, populations are often at low density. In these circumstances, a conservative approach to moose population management is advised (Tyers unpublished data, Gasaway 1997, Karns 1997).

Some information on moose populations in the GYA is available. Houston (1982) reported that moose remains have not been found in archeological sites in northwest Wyoming or south central Montana. He concluded that moose had not yet occupied northwest Wyoming in 1830 (Houston 1968), but had colonized the Yellowstone area by the 1870s; they appeared on Yellowstone's northern range around 1913 (Houston 1982). Schullery and Whittlesey (1992) reviewed the documentary record for wolves and related wildlife species in the Yellowstone National Park area prior to 1882. Based on historic accounts, they concluded that moose were common in the southern part of the park in 1882, and rare sightings were made near or on the northern range about the same time.

Recent studies indicate a population decline following the 1988 Yellowstone fires in areas where fire effects were severe and in areas where moose rely on older lodgepole pine forests for winter range (Tyers unpublished data, Tyers and Irby 1995). In response to these data, Montana Fish, Wildlife and Parks has significantly reduced hunting quotas in districts north of Yellowstone National Park (T. Lemke, Montana Fish, Wildlife and Parks, personal communication). In portions of the GYA where moose have different winter-use patterns or where fire effects are not an issue, the trend may be different.

Several hypotheses have been proposed to explain the biogeography of moose in western North America. Kelsall and Telfer (1974) presented five hypotheses to explain the relatively recent expansion of moose. These include: (1) moose have had a limited amount of time to colonize North America since the last glaciation; (2) climatic variation—the Little Ice Age and associated severe winter weather limited moose populations around

1700–1800; (3) disease once limited moose numbers; (4) European settlement modified the original climax forests, which were poor moose habitat, and created seral vegetation types that moose prefer; and (5) predators once limited moose, but the near extermination of native carnivores allowed moose to extend their range and expand their populations.

Kay (1997) proposed a sixth hypothesis: moose were extremely vulnerable to predation by Native Americans who had no effective conservation practices. The result was a control of moose biogeography by native hunting.

Loope and Gruell (1973) proposed a seventh hypothesis specific to the GYA: a very low moose population during the 19th century was the result of fires, which maintained early successional vegetation. They speculated that moose populations have increased in this century in northwest Wyoming as forests have matured under a management policy of fire suppression. A primary factor in this, they believe, is an increase in subalpine fir, a shade-tolerant species found in older forests. They further hypothesized that subalpine fir is the staple food item in the diets of moose in the area. Tyers (unpublished data) tested this hypothesis and demonstrated that moose along the northern border of Yellowstone National Park feed primarily on subalpine fir saplings in older lodgepole forests.

Although the Shiras moose is a relatively recent arrival to the GYA, available habitat is now occupied. However, future population trends are uncertain. Habitat conditions, human influences, and exposure to predation vary considerably across the GYA. In addition, the small home range size of moose and the strong fidelity moose show to a geographic area tend to create many fairly discrete populations. For these reasons, it is likely that local populations will display very different trends.

As evidenced by the hypotheses for recent moose range expansion explained above, future trends in the GYA will be largely determined by predation and habitat quality. Humans, bears, and wolves prey upon moose in the GYA. The recent reintroduction of wolves is an important variable with unknown consequences. Some have speculated that wolves will play a major role in regulating moose populations, and a decrease in moose numbers will be noticed (Messier et al. 1995). The 1988 Yellowstone fires were a landscape-level disturbance that affected the successional stage of vegetation. This will undoubtedly be a determining factor for moose populations in a large spatial and temporal context. In many parts of the GYA, a return to an early successional stage represents a decrease in moose winter habitat that will reduce carrying capacity (Tyers unpublished data). Riparian areas with deciduous vegetation are important foraging areas for moose. They are limited in size and distribution and are particularly vulnerable to human impacts. Management of these areas will also play a role in determining moose population trends.

LIFE HISTORY

Moose are seasonal breeders with the mating season in the fall and calving in the spring. Most cows ovulate for the first time between 16 to 28 months of age, although those in populations on poor range may not breed until 40 months. Most cow moose produce either single or twin calves. Twinning varies widely across North America and may be correlated to habitat quality and carrying capacity. Triplets have been reported but are rare. Most cows produce a calf or calves each year. Neonatal predation is common and can be high (Schwartz 1997). Average life span is highly variable; generally, it may be 7 or 8 years with a maximum age at possibly 20 (Ballard and Van Ballenberg 1997).

HABITAT

As a generalization, the moose is an animal of the boreal forests—the coniferous forests that occur in a broad band across northern North America and Eurasia. Boreal forests also extend southward at higher elevations in the mountains. The climate within this biome is characterized by cold winters and short, mild summers (Brewer 1994). Food and cover are the primary factors limiting geographic distribution in the north (Kelsall and Telfer 1974), and climate is the factor in the south (Reneker and Hudson 1986). The most critical factor, especially to the southern distribution of moose, is temperature (heat) (Karns 1997).

Moose are browsers—herbivores that eat primarily shrubs and trees (Peterson 1955, Renecker and Schwartz 1997). Specifically, they eat twigs and foliage high in cell-soluble sugars that ferment readily in the rumen. These are foods that are considered to be, comparatively, of poor quality. In addition, they are characterized as concentrate selectors. Because of their body size, they require large amounts of abundant food to survive. To satisfy this need, they seek out concentrations or patches of biomass in the environment where they can spend relatively long periods of time foraging. For example, moose seek out or select willow (*Salix* spp.) that often offers large amounts of forage bunched together on the landscape. Because of their dietary constraints, the quantity of biomass for foraging determines moose density.

The large body size of moose is an advantage in boreal regions for coping with predators and periods of extreme cold and deep snow (Renecker and Hudson 1986, 1989). However, it also imposes limitations on activities. Moose have a difficult time dissipating heat, and heat stress can lead to a reduction in overall activity during warm periods. Ambient air temperatures above 23° Fahrenheit in winter and above 57° Fahrenheit in summer can be stressful and can cause moose to seek cooler areas. In a broader sense, problems with thermal regulation restrict range expansion into more temperate climates.

Telfer (1984) placed moose habitat in six broad categories: boreal forests, mixed forest, large delta floodplains, tundra, subalpine shrub, and stream valleys. These may be further described as either permanent or transitory in nature (Geist 1971, Peek 1997). Permanent habitats are those that persist and do not succeed over time to a different pattern of vegetation. For example, alluvial habitats are dynamic in that flooding and streambed alteration produce a constantly changing system, but they are permanent in the sense that the same type of vegetation is present after a disturbance. Boreal forests are more transitory. Fire can radically alter the vegetative composition; a mature forest can be changed to a shrub community. The shrub community will eventually be dominated by a forest that is vulnerable to a fire event just as the first one was. The pattern is cyclic, and each successional stage is transitory to the next.

Throughout much of their range, moose are found in transitory habitats. Specifically, they are closely linked to early seral stages where shrub biomass is plentiful (Dryness 1973, Wittinger et al. 1977, Irwin and Peek 1979). In many areas, moose benefit from the removal of the forest canopy (Taber 1966, Krefting 1974, Kelsall and Telfer 1974, Leresche et al. 1974, Irwin 1975, Peek et al. 1976). Disturbances such as fire, logging (or other forms of mechanical manipulation), disease, or wind events can create favorable moose habitat by removing trees that compete for resources with shrubs.

However, it is also known that moose winter habitat-use patterns can be highly variable between regions and years (Peek 1974a), which reflects adaptive responses to different environmental conditions. Peek (1974a) cautioned against making unequivocal generalizations about moose winter habitat selection and suggested that the amount of variability can make these descriptions misleading. Included are statements about the role of transitory habitats, forest canopies, and seral stages in moose habitat. He stated that this variability has special consequences to management because it is important to determine the forage species locally preferred by moose and then favor those species through management actions.

Snow conditions have an important influence on moose habitat-use patterns (Peek 1997). Conditions include temperature, density, hardness, and depth (Peek 1997), and factors that affect the ability of moose to access browse (Peek 1971, Schladweiler 1973). The presence or absence of a forest canopy can have a significant effect on snow conditions. For example, moose often prefer open brush fields for foraging where browse is abundant. They have also been known to seek coniferous forests when snow conditions impeded movements in open areas (des Mueles 1964, Kelsall 1969, Telfer 1984, Peek et al. 1976, Rolley and Keith 1980, Thompson and Vukelich 1981). Travel in forests is often less energy demanding because tree branches ameliorate snow density, hardness, and depth through shading and intercepting falling snow.

Several studies have reported specific snow depth thresholds for moose. Snow depths of 25.5 inches have been reported to affect habitat use and movements of moose (Kelsall 1969, Thompson and Vukelich 1981, Pierce and Peek 1984). In Quebec, des Mueles (1964) found that moose shifted to more dense coniferous areas when snow depth reached 30 to 34 inches, and moose did not use areas where the snow exceeded 42 to 48 inches, even when the snow was soft. Kelsall (1969) reported moose were severely restricted by snow depths of 27.5 to 35.5 inches. Kelsall and Prescott (1971) found that when snow depths reached 38 inches in New Brunswick moose where confined to areas with high forest canopies. Tyers (unpublished data) demonstrated that moose on Yellowstone's northern range avoided snow depths greater than 31.5 to 43 inches and were not found when snow exceeded 54.5 inches.

Peek (1974a) reported on the variability in the winter habitat used by moose in North America. He reviewed 41 different reports: 13 from the Intermountain West; 6 from Alaska; and 22 from Canada, Minnesota, and Maine. His review highlighted the variation and commonality in the diet and forest successional stage used by moose. In another document (1974b) he focused on the Shiras moose. He identified five different types of winter habitat for the Shiras moose in the Intermountain West, an area that includes the GYA:

1. Willow bottom/stream/conifer complex occurring along high-gradient streams.
2. Flood plain riparian community containing extensive willow stands.
3. Drainages where willow-bottom communities are very limited and are of little importance to moose, but where conifer and aspen types are important, and the diet is more varied than in areas where willow is plentiful.
4. Arid juniper hills.
5. Willow communities that are important but are neither limited nor extensive. Moose are forced from these areas by snow conditions into adjacent forested slopes where subalpine fir stands support low-density moose populations in winter.

Studies conducted in the GYA portion of the Intermountain West accent the variability of moose habitat use. The results generally fit into one of Peek's (1974b) five categories, but there are important differences in habitat use by moose in this area and the moose of other areas. For example, McDowell and Moy (1942) did a descriptive study of moose habitat use in the Hellroaring/Slough Creek area north of Yellowstone National Park (Peek's Type 5). They noticed an early winter association of moose and the limited willow areas, and then a move to adjacent conifer types, presumably in response to increasing snow depths. Harry (1957) and Houston (1968) documented use by moose of the extensive willow areas on the flood plains of Jackson Hole, Wyoming (Peek's Type 2). Stevens (1970) found Douglas fir and aspen communities to be the key winter range in the Gallatin Mountains (Peek's Type 3). Tyers (unpublished data, Tyers and Irby 1995) investigated moose habitat use on Yellowstone's northern range and documented moose using older lodgepole pine forests during the most difficult winter months where they browsed almost exclusively on subalpine fir saplings and seedlings (Peek's Type 5).

HUMAN ACTIVITIES

There are few examples in the literature that describe the effect of various types of human activity on wintering moose. Although several studies address changes in movements and habitat use, none appear to demonstrate resulting demographic changes.

Moose are thought to be comparatively tolerant of humans and to have the ability to develop a high level of habituation (Shank 1979). This is illustrated in several ways, including flight distance. Moose unaccustomed to humans usually run about 150 yards, but habituated individuals may allow approaches to within 20 to 25 yards (Shank 1979). As a further example, Westworth et al. (1989) found that moose in British Columbia were able to habituate to disturbances associated with surface mining, including vehicular traffic, plant machinery, and blasting of ore reserves. Pellet group densities, used as an index of moose abundance, were highest on a transect 100 yards from the open pit. This transect had a particularly high density of browse leading the authors to concluded that moose distribution was influenced more by browse availability among different habitat types than by disturbance associated with mining. Pellet groups also demonstrated moose activity as close as 15 yards from the pit at sites where browse was present.

The response of moose to the mine in British Columbia (Westworth et al. 1989) and similar situations may be explained by a theory proposed by Geist (1971). He stated that if visual and acoustical stimuli are predictable in space and time, the process of habituation by wildlife is enhanced. Mine activity and some forms of winter recreation can be predictable. In contrast, panic responses may occur as a result of any kind of abrupt unexpected intrusion (Busnel 1978).

Westworth et al. (1989) proposed that the mine was actually an asset to moose. Moose in the area are exposed to predation by wolves. The mining activity displaced wolves, offering security to moose not available away from the mine site.

Rudd and Irwin (1985) investigated impacts to wintering moose resulting from oil and gas extraction and recreational activities in western Wyoming. The number of shrub species available in proximity to a plowed road was the best predictor of moose presence or absence. Relative to people on snowshoes, skis, or snowmobiles, trucks associated with resource extraction caused the greatest disturbance to moose. People on snowshoes or skis caused more disturbances than snowmobiles. The average distance 18 moose ran to escape trucks was 16.9 yards, and the average distance at which moose where displaced was 169 yards; 21 percent were displaced, and 48 percent showed some type of disturbance behavior. The average distance 19 moose moved away from people on snowshoes or skis was 16.6 yards, and the average distance at which moose were displaced was 80.7 yards; 17 of the 19 moose moved to a different location, and all showed signs of disturbance. The average distance 242 moose ran to escape a snowmobile was 10.5 yards, and the average distance at which moose were displaced by snowmobiles was 59.25 yards; 50 percent of the encounters between moose and snowmobiles resulted in displacement while 94 percent showed some form of disturbance. Rudd and Irwin (1985) recommended that winter recreational use and mine activity be restricted near preferred moose winter range.

Ferguson and Keith (1983) addressed the influence of nordic skiing on moose and elk in Elk Island National Park, Alberta. They found that cross-country skiing influenced the general over-winter distribution of moose. Moose tended to move away from areas near heavily used trails more than lightly used trails during the ski season (January through March). Daily movements away from trails occurred after the onset of skiing. However, once displacement occurred, additional skiers did not generate a greater displacement.

The flight behavior of moose is unusual and often misinterpreted. Their reputation of being tolerant to humans may in part be because their stress response is more subtle than that of other ungulates. Shank (1979) reported a common response of moose to a disturbance was that they rarely reacted immediately and overtly to disturbing stimuli unless that stimulus was very intense. Often, they continued feeding and might even increase the intensity of feeding. While this is occurring, they moved without obvious sign of stress toward cover. Once cover was reached, they usually looked directly at the source of the disturbance, often for the first time, and then ran. Until the moose bolts, stress may not be obvious because it is expressed in less noticeable physiological responses, such as increased breathing and elimination rates.

Reports dealing specifically with collisions between wintering moose and vehicles and trains are more common. Examples can be found from most areas with important moose populations. Because winter recreation frequently involves plowing roads and accessing recreation areas with motorized conveyance, the topic is relevant.

Lavsund and Sandegren (1991) reviewed moose/vehicle relations in Sweden and described the situation as a serious problem both in terms of human safety and mortality of moose. Risk was highest at dawn and dusk and higher at night than during the daytime. In southern Sweden where winter snow accumulation is less important, collisions peak in early summer during calving and in autumn during the rut. In northern Sweden, collisions peak during December and January when snows initiate moose migrations to lowland ranges where major roads are common. Various methods were tried to reduce the number of moose/vehicle collisions. Repellants in the form of flashing lights, sounds, and scents were not effective. The results of roadside clearing to improve visibility for drivers demonstrated a reduction that was no better than what might have been arrived at by chance. Efforts to educate drivers on how to scan the roadside and anticipate risks did not seem to change driver behavior—good drivers were cautious, and bad drivers remained incautious. Neither road authorities nor drivers were interested in reducing the speed limit. Fencing the roads was effective at reducing collisions by 80 percent.

In Alaska, measures were taken to mitigate moose/vehicle collisions along a stretch of highway that was improved (Child et al. 1991). A moose-proof fence, moose underpass, and highway lighting all were effective at significantly reducing collisions. Collisions were reduced 95 percent in the fenced portion of the highway when compared to the previous decade before the highway was improved and mitigation measures were put in place. The reduction in loss of moose allowed an increase in hunter harvest. Child et al. (1991) estimated that approximately 10 percent of the annual allowable harvest in the province of British Columbia die as a result of collisions on highways and railways. The impact of this on the demographics of the moose population is unknown.

Collisions between moose and motorists on the Kenai Peninsula, Alaska, were also reported to be a severe problem (Del Frate and Sparker 1991). The number of road-killed moose nearly doubled following the new policy of the Department of Transportation to improve snow-clearing efforts. Better road conditions allowed motorists to travel faster. Collisions also increased during a severe winter when moose sought relief from harsh snow conditions by attempting to winter close to plowed roads. In response, a public awareness program was started using roadside signs, bumper stickers, and programs in schools. The number of moose mortalities declined 18 percent the following year, but the authors were not confident the education program was responsible. The results were confounded by mild winter conditions that allowed moose to winter farther from the roads. As mitigation, they called for avoiding building roads in moose winter range, brushing roadsides to increase visibility, and fencing.

Rudd and Irwin (1985) found that site features had some effect on how moose tried to escape humans. When exiting roads freely, moose selected areas with less steep slopes than random samples, especially slopes of less than 5 percent. In 83 percent of the cases, moose exited at points where snow depth along the road was less than the average depth, although this difference was not statistically significant. During forced exits, moose chose slopes in proportion to what was available. The average snow depth of the berm was significantly greater along the road than where moose exited under duress. The average canopy closure was significantly greater at these exit spots than in random samples.

Bubenik (1997) reported that mature, healthy moose stand their ground when confronted by wolves, and inexperienced moose generally run and are killed. Child et al. (1991) and Bubenik (1997) saw a connection between this and the high incidence of collisions with trains. Moose use the same survival strategy during confrontations with trains as they do with wolves. With trains this tactic is fatal. The problem is exacerbated by the effect of headlights, which hypnotize moose and interfere with avoidance movements.

Anderson et al. (1991) determined that snow conditions greatly influenced annual variation in moose killed by trains in Norway. Mean annual snow depth was able to explain 84 percent of the annual variation in train kills. They believed three factors were responsible for this close correlation. First, early snows seemed to increase the speed, timing, and magnitude of moose movements to winter range. This places them on train tracks earlier in the season. Secondly, although moose are morphologically adapted for survival in snow, snow depths of greater that 39 inches seemed to motivate moose to seek the plowed railroad beds for movements between feeding sites.

Third, as snow depths increased moose were less successful at escaping the tracks in the face of oncoming trains. Because of snow conditions they returned to solid ground on the tracks and tried to outdistance the approaching train instead of climbing over the snow berm. In addition, more collisions occurred after dark when moose were more active; they became hypnotized by train lights and train personnel had greater difficulty observing moose. They also found temperatures below 20° C tended to increase the risk of collision, while temperatures above 0° C had the opposite effect. The authors speculated this occurred because moose are foraging more actively at lower temperatures.

Becker and Grauvogel (1991) investigated moose/train collisions in Alaska. They observed that most moose that were struck were using the tracks as a travel corridor in a winter environment. Most had time to exit the tracks but, instead, usually tried to outrun the train. Snow depths were around 35.5 inches, and moose that did leave the tracks floundered and returned to the tracks, which probably increased their sense of vulnerability to a perceived predator, the train. They experimented with decreasing the average speed of the trains (from 48 to 25 miles per hour) to see if moose mortalities could be reduced. The reasoning was that at a reduced speed there would be more reaction time for train personnel and more time for moose to escape. The reduction did not reduce the number of moose mortalities, and the train company determined that, based on economics, they could not afford to reduce the train's speed below 25 miles per hour. The authors believed that a threshold did exist below which a positive response would occur, but it appears to be below 25 miles per hour, which is not economically practical for the train company.

Modafferi (1991) also investigated the relationships between moose/train collisions, snowpack depth, and moose distribution. The setting was the lower Sustina Valley in Alaska. More than 73 percent of mortalities occurred from January through March. Mortality was greatest along stretches of railway that passed through moose winter range. As snow depth increased, mortalities increased.

POTENTIAL EFFECTS

The literature indicates moose can be impacted by human activities in the winter. However, moose habitat requirements are specific, and their use of selected areas is traditional. The presence or absence of moose winter activity is easy to verify through tracks, pellet groups, beds, sightings, and evidence of browsing. Investigations in summer or winter will demonstrate whether or not moose are using the area as winter range. As discussed, the specific attributes of moose winter range are variable. However, in all cases a winter range will include a concentration of accessible browse material such as deciduous trees and shrubs, especially willow and aspen. In some cases, browse may be subalpine fir saplings. Cover, in the form of dense coniferous forests, may also be present. Some of the best moose winter range is found where browse concentrations are in juxtaposition with cover. If snow conditions preclude access to the browse, moose will not be present.

Impacts of recreational use may take several forms. Moose may be negatively impacted by a loss of winter habitat if construction of facilities removes habitat features resulting in a loss of foraging opportunities or cover. Negative impacts may also occur if moose are subject to displacement that results in a drain on energy reserves. Because they are often in an environment where snow is deep, flight can be energetically costly. The literature indicates flight and stress are most likely when the source of the disturbance is unpredictable, is severe to sensory perception, and is in close proximity. There is also the possibility that if disturbances are not of this nature, moose may habituate to human activities and show high tolerance. Moose may even seek centers of human activity as security from predators.

Moose are also uniquely vulnerable to mortality by collisions with vehicles. This is because of the relationship between moose, browse availability, and snow conditions. Plowed roads or train tracks in moose winter range offer moose relief from snow conditions as well as travel corridors to sources of browse. This, combined with their instinctive response of standing their ground in the face of a perceived threat help explain why this is such a serious problem in many areas. Winters with above average snow depths exacerbate the problem.

Moose in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(1) Destination areas. Human activity at destination areas has the potential to negatively impact moose. Habitat can be lost if facilities are built in moose winter range. Individual animals can be affected if a flight response is initiated through contact with humans or their dogs. If human activities are predictable, moose may become habituated. If predation is intense, moose may even seek the site as a refuge.

(2) Primary transportation routes and (3) scenic driving routes. Human activity along driving routes has the potential to negatively impact moose. Habitat can be lost through road construction. Individual animals can be affected by collisions with vehicles or by energetically expensive flight responses.

(4) Groomed motorized routes and (5) motorized routes. Individual animals may be affected if a flight response is initiated by contact with vehicles. Moose may use the groomed surface as a travel route and invite collisions with oversnow vehicles. If human activities are predictable, moose may become habituated.

(6) Backcountry motorized areas. Because of the way humans recreate in these areas, it is unlikely their activities will be predictable to moose. Routes, time of day, and numbers of people will be highly variable. As a result, there is a high probability of initiating a flight response and a low probability of habituation occurring. In addition, there is a chance snowmobilers will approach or even chase moose because their movements are unrestricted. This could be energetically very expensive for moose.

(7) Groomed nonmotorized routes and (8) nonmotorized routes. Human activity may initiate energetically expensive flight responses. If human activity is predictable, some level of habituation may occur. Because established routes will be used, the chance that habituation will occur is enhanced. Moose may use groomed routes as travel corridors making encounters with people more likely. However, because the activity will not be motorized and grooming vehicles move slowly, collision is not a risk.

(9) Backcountry nonmotorized areas. Because of the way humans use these areas, it is unlikely their activities will be predictable to moose. As a result, there is a high probability of initiating flight response and a low probability of habituation occurring.

In addition, there is a chance that skiers will approach moose because their movements are unrestricted, which could be energetically expensive to moose. However, it is less likely skiers will actually chase moose.

(10) Downhill sliding (nonmotorized). These areas are usually limited in size. Unless they are located in especially productive moose winter range, impacts should be minimal.

(12) Low-snow recreational areas. Moose winter range is usually at higher elevation where snow accumulation is comparatively greater. More xeric habitats do not provide moose forage. A possible exception is riparian areas at low elevation that may be used by moose as winter range. In these instances, moose could be impacted by a loss of habitat or by displacement. However, flight responses would not be as energetically expensive as it would be in locations where snow conditions are deeper.

MANAGEMENT GUIDELINES

- Avoid building winter recreational facilities in moose winter range. This will prevent a loss of habitat and reduce encounters that elicit energetically expensive flight responses. As stated, moose winter range is not difficult to identify. All components of the wintering area should be considered, including foraging areas, cover, and travel corridors.
- Where human use does occur in moose winter range, regulate activities to make them as predictable as possible. This can be accomplished by restricting them spatially and temporally. For example, restrict skiing or snowmobiling to designated paths and to daylight hours.
- Where plowed roads exist in moose winter range, reduce the risk of collisions by plowing escape corridors in roadside snow berms, reducing speed limits, alerting motorists to the risk by signing and other educational efforts, providing roadside lighting, restricting travel to daylight hours, fencing road corridors, providing underpasses for moose to cross the road, and removing roadside barriers that limit visibility.
- Educate the public so that they can take appropriate measures to avoid impacting moose. They should understand the impacts of chasing or approaching moose and the importance of controlling the movement of dogs.
- A monitoring program should be established to follow moose population trends and assess potential conflicts with moose. A variety of methods are available with which to develop either an index with comparatively little investment or to conduct a more intense survey (Tyers unpublished data; Timmermann 1974, 1993; Gasaway 1997).

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EFFECTS OF WINTER RECREATION ON MOUNTAIN GOATS

POPULATION STATUS AND TREND

Mountain goats (*Oreamnos americanus*) were historically distributed in North America in the western coastal ranges from Alaska to northern Washington and in the Rocky Mountains from northern Canada to northern Montana and central Idaho. Through introductions, primarily by state wildlife agencies, their distribution has been successfully expanded into vacant habitats in their historic range, as well as in habitat outside their historic range in the western United States (Johnson 1977, Wigal and Coggins 1982). Mountain goats were introduced into the Greater Yellowstone Area (GYA) by state fish and game agencies in Montana and Idaho for recreational purposes, including hunting (Brandborg 1955, Montana Department of Fish and Game 1976, Hayden 1984, Swenson 1985, Laundre 1990, Varley 1995). Most introductions took place between 1940 and 1960 and were successful in achieving self-sustaining populations. Many of the founder herds were productive and colonized unoccupied areas, including mountain ranges that did not receive transplants, such as the Gallatin Mountains. Currently mountain goats inhabit most mountain ranges with appreciable alpine habitat in the GYA (see Table 2). The population trend for goats in these areas is generally stable or growing (Swenson 1985, Laundre 1990, Lemke 1996), and most herds sustain a conservative annual harvest.

LIFE HISTORY

Mountain goats are social animals generally found in small groups (Brandborg 1955, Chadwick 1977), though single individuals are commonly encountered. During most of the year, adult males generally avoid adult females except where centralized resources, such as mineral licks, bring them together. Males court females during the breeding season in November and early December then leave the female group sometime during the winter (Brandborg 1955, Chadwick 1973, Smith 1977, Wigal and Coggins 1982).

Mountain goat populations are generally considered to be slow growing and have low productivity (Eastman 1977, Stevens 1983, Chadwick 1983). Goats become sexually mature at the age of 2.5 (these goats give birth

Table 2. Mountain ranges in which goats are found in the Greater Yellowstone Area

Mountain Range	Population[1]	State	References[2]
Absaroka Range	360–490	MT, WY	Swenson 1985, Varley 1995
Beartooth Mountains	365–425	MT, WY	Haynes 1992
Bridger Range	85–90	MT	
Centennial Mountains	No estimate	ID, MT	
Crazy Mountains	175–200	MT	Lentfer 1955, Saunders 1955, Foss 1962
Gallatin Mountains	50–60	MT, WY	
Gravelly Range	No estimate	MT	
Madison Range	No estimate	MT	Peck 1972
Palisade Range	128–142	ID, WY	Hayden 1984, 1989
Tobacco Roots	No estimate	MT	

[1] 1993 estimates from surveys conducted by Montana Fish, Wildlife and Parks from Lemke (1996).

[2] General population status, distribution, and ecology information specific to these populations.

at 3) or 3.5 (these goats give birth at 4), depending upon conditions (Houston and Stevens 1988), though productive conditions can, in rare cases, lead to maturity at the age of 1.5 (Stevens 1983). Gestation is about 6 months, and offspring are born in late May or early June. Females most often have one offspring. Though two and even three kids have been documented, it is considered rare and an indication of productive conditions (Lentfer 1955, Foss 1962, Hayden 1984, Houston and Stevens 1988, Festa-Bianchet et al. 1994, Varley 1995). Mountain goat kids often remain with their mothers for 10–11 months, or longer if the mother does not produce a new kid. Because of social aggression, the association between a mother and kid can be critical to kid survival during winter (Chadwick 1977). At age two or three, males leave female groups and join male groups or become solitary, while females typically stay with groups (Brandborg 1955, Wigal and Coggins 1982, Chadwick 1983). Both sexes are capable of dispersing long distances and often will at young ages (Chadwick 1973, Stevens 1983, Hayden 1989, Varley 1995).

The greatest factor in natural mortality of mountain goats appears to be winter severity and, in particular, snow depths (Adams and Bailey 1982, Wigal and Coggins 1982, Swenson 1985). Snow depth and snow morphology are often the underlying factors in the causes of death in mountain goats. Causes of death include the availability of winter forage and its effect on body condition (Brandborg 1955, Edwards 1956, Holroyd 1967); the frequency of intraspecific interactions and the resulting levels of stress (Petocz 1972, Chadwick 1977, Kuck 1977, Smith 1977, Foster and Rahs 1982); the susceptibility to accidents, including avalanches and falls (Holroyd 1967, Chadwick 1983, Smith 1984); the susceptibility to disease and parasites (Wigal and Coggins 1982); and the susceptibility to predation (Brandborg 1955, Holroyd 1967, Foster and Rahs 1982). Of all natural causes, accidents related to avalanches; rock, snow, and ice fall; and precipitous falls appear to account for most natural deaths (Brandborg 1955, Holroyd 1967, Foster and Rahs 1982, Wigal and Coggins 1982, Chadwick 1983, Smith 1984).

HABITAT

Throughout their range, mountain goats inhabit steep, rocky terrain during all seasons of the year. No other feature of preferred habitat is more apparent than the rugged inclines to which goats are adapted. They are often found on slopes between 20 and 60 degrees with little vegetative cover (Smith 1977, Varley 1995). They use cliff ledges for all activities including resting, feeding, and playing (Chadwick 1973, McFetridge 1977). They also use the slide-rock, talus, and turf meadows adjacent to ledges, though they rarely stray far from the safety of cliff habitat (Saunders 1955, McFetridge 1977, Varley 1995).

Goats typically migrate between summer and winter ranges each fall and spring (Brandborg 1955, Holroyd 1967, Kuck 1977, Smith 1977, Wigal and Coggins 1982). These migrations are often short-distance elevational shifts to adjacent areas, versus the lengthy migrations to distantly separated ranges known to occur with mountain sheep and elk (Holroyd 1967, Chadwick 1973, Varley 1995). The use of transitional ranges between summer and winter ranges is atypical (Kuck 1977).

In the Rocky Mountains, summer ranges are often high-elevation settings such as the tops of mountain ridges and peaks above timberline (Brandborg 1955, Holroyd 1967, Wigal and Coggins 1982). In the GYA, these areas are typically between 8,500 and 12,000+ feet in elevation. During the summer months, goats use alpine meadows, slide-rock slopes, talus, and cliff ledges and usually avoid timbered areas (Saunders 1955, McFetridge 1977, Thompson 1981, Varley 1995).

Goats descend to lower elevations in autumn, often after the first deep snowfall, and use terrain topographically similar to their high-elevation habitats. In some populations, goats remain in high-elevation areas during the winter and feed on very steep and/or wind-blown slopes and ridges where snow does not accumulate (Brandborg 1955, Saunders 1955, Hebert and Turnbull 1977, Wigal and Coggins 1982), however, most populations have winter ranges distinctly lower in elevation (Brandborg 1955, Chadwick 1973, Kuck 1977, Wigal and Coggins 1982). Winter habitats can be below timberline, varying in elevation depending upon local topography, though the particular areas in use for non-coastal populations tend to be non-forested areas or open-canopied forests (Gilbert and Raedeke 1992).

The principal factors in mountain goat winter range habitat selection seem to be close proximity to cliff habitats and low snow accumulations (Brandborg 1955, Smith 1977, Smith 1994). Thus, the preferred habitats are often steep and rocky, located on south-facing slopes, and exposed to wind and sun (Brandborg 1955, Chadwick 1973, Gilbert and Raedeke 1992, Smith 1994, Varley 1995). Brandborg (1955) noted that goats in Montana and Idaho used the lowest available winter ranges that provide preferred combinations of broken terrain and vegetative cover. Smith (1977) found wintering goats in the Bitterroot Range used cliff habitats more than 70 percent of the time observed. Kuck (1977) found the selection of winter habitat for goats in the Lemhi Mountains of Idaho was determined by the physical snow-shedding characteristics of an area rather than the forage types present.

Wintering goats show strong affinity for local sites where they restrict their movements dramatically in comparison with summer. The resulting distribution is often confined to critically small islands of habitat (Kuck 1977). In the Bitterroot Range, 36 goats occupied a linear distance of 3 miles throughout the winter (Smith 1977). Similarly, 17 wintering goats used 8.6 acres in the Swan Range of northern Montana (Chadwick 1973). In very severe winters, goats continue descending to lower elevations (Rideout 1977) or ascend to wind-swept ridges or mountain tops (Hjeljord 1973).

Various winter ranges in the GYA have been described. Peck (1972) reported goats using the Spanish Peaks area of the Madison Range moved to lower elevation winter ranges in Jack Creek and the Beartrap Canyon of the Madison River. Similarly, goats on the Beartooth Plateau are known to descend into the rocky canyons of drainages on the eastern front, including the Clarks Fork Canyon in Wyoming. There, they may be found as low as 5,000 feet in elevation. Mountain goats in the Crazy Mountains are thought to stay close to alpine areas using wind-swept ridges and cliffs (Lentfer 1955; T. Lemke, Montana Fish, Wildlife and Parks, personal communication). In the Absaroka Range, goats are thought to descend to low, south-facing slopes and cliffs adjacent to summer ranges (T. Lemke, Montana Fish, Wildlife and Parks, personal communication; Varley 1995). One area of the Boulder River Canyon, which had steep semi-forested rock outcrops, was used by goats from the Absarokas in 1994 (Varley 1995).

HUMAN ACTIVITIES

Mountain goats are one of the least understood of all big game mammal species in North America (Eastman 1977, Chadwick 1983). Management has principally focused on the need for better population information and methods for setting harvest quotas (Brandborg 1955, Eastman 1977, Wigal and Coggins

1982). Eastman (1977) assessed research needs for goats in the U.S. and Canada and found non-hunting impacts resulting from human disturbance ranked within the top third among management priorities, though very little had been done on the subject.

Some human disturbances have been shown to alter goat behavior, and disturbance can affect physiology, distribution, habitat use, fecundity, and, ultimately, population health (Penner 1988). However, there is little known about winter recreation disturbances and their effects on mountain goats.

Throughout North America, some goat populations have been adversely affected by human developments, including logging (Chadwick 1973, Hebert and Turnbull 1977, Smith and Raedeke 1982) and mineral, coal, gas, and oil development (Hebert and Turnbull 1977, Pendergast and Bindernagel 1977, Smith 1982, Joslin 1986). These cases have predictive value for estimating the general effects of continual disturbance through human activities. In these cases, a decline in goat population levels occurred when development in or near goat habitats took place. The mechanisms for population declines were not clear but seem to be related to improved access for hunting or poaching (Chadwick 1973, Foster 1977, Hebert and Turnbull 1977, Smith and Raedeke 1982, Smith 1994), abandonment of habitat due to alterations or disturbance (Chadwick 1973, Hebert and Turnbull 1977, Pendergast and Bindernagel 1977), or continual stress as a result of human presence (Joslin 1986).

Controlling human access has been continually suggested as the management tool that will have the greatest effects on the long-term health of mountain goat populations (Chadwick 1973, 1983; Eastman 1977, Hebert and Turnbull 1977, McFetridge 1977, Wigal and Coggins 1982, Joslin 1986, Haynes 1992). Joslin (1986) states, "Motorized access in or near mountain goat habitat is probably the single biggest threat to goat herds throughout North America."

Several authors have looked at the effects of human disturbance on goats in the form of proximity to people, traffic, and noise during summer (Holroyd 1967, Singer 1978, Thompson 1980, Singer and Doherty 1985, Pedevillano and Wright 1987). Goats have shown tolerance, and, in cases without harvest or harassment, the ability to readily habituate to humans on foot as well as road traffic (Bansner 1978, Stevens 1983, Singer and Doherty 1985, Pedevillano and Wright 1987, Penner 1988). Penner (1988) writes, "Goats are adaptable and can habituate to potentially adverse stimuli if they are gradually acclimatized and negative associations are avoided." This possibility is best achieved when stimuli sources are localized and highly predictable (Penner 1988, Singer and Doherty 1985). Sudden, loud noises, however, from traffic (Singer 1978, Singer and Doherty 1985, Pedevillano and Wright 1987), blasting or drills (Singer and Doherty 1985, Penner 1988), and helicopters (Penner 1988, Coote 1996) still elicited extreme alarm responses from goats that have been habituated to human presence.

Many observers have found that goats that are approached on foot are either mildly evasive, tolerant, or curious. Consequently, these observers believe that most human foot traffic is of minimal impact to goats (Brandborg 1955, Holroyd 1967, Thompson 1980, Pedevillano and Wright 1987). Although quite rare, confrontations with aggressive goats have been reported when humans and goats come into close quarters (Holroyd 1967, Chadwick 1983). Goats react by stamping their front feet, pawing the ground, and arching their necks when threatened by humans (Holroyd 1967). Quick, powerful movements coupled with very sharp horns can cause serious injury to humans in the course of handling goats. Anecdotal reports of goats on the Beartooth Plateau attest to the occasional aggressive nature of goats around humans. Driven by hunger for minerals, these goats have, on occasion, come into human camps knocking down tents and equipment.

Some biologists in the GYA have expressed concern about potential conflicts between humans and goats, but there are no documented, actual, ongoing conflicts. Outside the GYA on the Sawtooth National Forest and Sawtooth National Recreation Area in Idaho, special management restrictions on winter recreation, including foot, snow machine, and helicopter travel, have been established. Mitigation measures, including area restrictions, closures, and other regulations, were enacted to minimize the potential for disturbances to wintering goat populations (Hamilton et al. 1996, USFS 1997).

POTENTIAL EFFECTS

Human activities are capable of causing disturbances detrimental to mountain goat populations. While the cases that exist do not specifically refer to winter recreation, they do demonstrate the process by which human impact may alter goat behavior, habitat use, and stress levels potentially leading to population declines. Because of low productivity and narrow habitat requirements, goats can be considered a fragile wildlife resource, particularly while on winter ranges (Smith 1982, Chadwick 1983, Smith 1984, Wigal and Coggins 1988).

Because of the remote and rugged nature of goat wintering habitats, recreational use of such areas is unlikely. However, any use could potentially be detrimental. Abandonment of habitats or increased stress related to frequent encounters could be elicited through recreational activities including snowmobiling, skiing (downhill, cross-country, or telemark skiing accessed by helicopter or from the ground), snow-boarding, and ice-climbing.

Because mountain goats are sensitive to loud noises, snowmobiles and helicopters could affect their behavior depending upon the proximity and duration of the disturbance (Singer and Doherty 1985, Pedevillano and Wright 1987, Côté 1996). In the GYA, most occupied goat winter range occurs within established national wilderness areas where motorized travel is strictly prohibited. In assessing management considerations, the Idaho Department of Fish and Game identified use of helicopters for skiing as an activity potentially detrimental to goats. Where the two are in conflict, goats require protection (Idaho Department of Fish and Game 1990).

Nonmotorized users in close proximity to wintering goats may also affect goats in terms of the energy expended to avoid these users. Depending upon winter severity, energy expended avoiding recreationists could be costly and, therefore, cause harm to individuals and, in the long-term, to populations. Biologists have expressed concerns about an increasing amount of ice-climbing taking place in mountain goat habitats. The extent of this potential disturbance is unknown. Ice climbing may need to be monitored as a potential source of disturbance in particular situations, although, because it is a highly localized activity lacking loud noises or other disturbance factors, long-term effects would likely be minimal.

Although accounts of goats injuring humans exist, goats generally do not pose a safety hazard to humans. Only in unusual cases involving habituated goats in frequent, close proximity to humans would such a concern exist.

Mountain goats in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(6) Backcountry motorized areas
(8) Nonmotorized routes
(9) Backcountry nonmotorized areas
(12) Low-snow recreation areas

Given the susceptibility of mountain goats to human disturbance, particularly during the months of winter, there is potential for negative impacts to goats as a result of winter recreational activities. However, there are no known cases of conflict in the GYA at this time. Seemingly, conflicts are being avoided between winter recreationists and mountain goats. Possible explanations for this conclusion include:

1. Conflicts may be occurring that are unknown to officials. It would be likely that any major conflicts would not escape attention, though the occasional, minor conflict could go unreported for some time. Minor conflicts may occur in association with wilderness trespasses and, thus, remain unreported or undetected. In most cases, it appears that wilderness designation and area use limitations have adequately protected mountain goat habitats from motorized-related disturbances in the GYA.
2. Because mountain goat winter range is inaccessible and precipitous, goats and recreationists are not often coming into conflict. For recreation, humans tend not to seek the combination of rocky, rugged terrain, and low-snow conditions required by mountain goats. Rather, snowmobilers and skiers prefer deep snow conditions, which are typically avoided by goats. The discrepancy in site preferences appears to be a factor in mutual avoidance by goats and humans during winter. While ice climbing does occur in goat winter range habitats, the effects of this form of recreation are unknown. Ice climbing is localized at specific sites and is predictable in terms of repeated use. These are two characteristics that goats seem to require for tolerance or habituation; therefore, ice climbing may not pose a significant threat to goats.

MANAGEMENT GUIDELINES

The impacts of human disturbance on goat populations have been clearly demonstrated in numerous cases; however, these cases conspicuously lack a clear case demonstrating the effects of recreation on goats during winter. Based on no known cases of conflict in the GYA, no immediate management recommendations are offered. If, however, cases of conflict occur in the future, restrictions on human use should be implemented to protect mountain goats. Such restrictions might include area closures, a permitting system that would regulate visitor numbers, and criteria for the use of helicopters in the area of mountain goat winter range.

A general lack of information on the winter habits and resource requirements for mountain goats may require further ecological studies. It would be useful to more specifically locate mountain goat winter ranges in the GYA and compare them with backcountry recreation use areas. Overlap can then be examined so that potential areas for conflict can be identified. If a significant overlap exists or conflict arises, management options can be considered and implemented.

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EFFECTS OF WINTER RECREATION ON SUBNIVEAN FAUNA

Subnivean fauna are small animals that live under the snow during the winter. They include such species as shrews, voles, pocket gophers, and mice.

LIFE HISTORY

Subnivean mammals are often active both day and night and are active throughout the year. They spend most of their time in or on the ground, and, during winter, they are most often found under the snow. Generally they are short lived but have relatively high reproductive rates.

These mammals eat a wide variety of foods that can be obtained from above or below the ground. Shrews eat primarily insects, other invertebrates, and some small mammals. A vole's diet may include green vegetation (grasses, seeds, grain, and bark). Tubers, roots, and some types of surface vegetation are preferred by pocket gophers, and mice generally feed on seeds, insects, or green vegetation.

Ecologically, these mammals are important prey species for a wide variety of birds and mid-sized carnivores.

HUMAN ACTIVITIES

It has been suggested that compacting snow by mechanical grooming or even by substantial activity on foot (skiing or snowshoeing) could have a negative impact on small mammals that spend their time under the snow in the winter.

POTENTIAL EFFECTS

The subnivean environment protects life below the snow from some impacts of winter, such as wind and cold. The environment under the snow has relatively stable temperatures, and the loss of energy from the organisms that live there is slowed. However, factors such as light, carbon dioxide, oxygen, and moisture may have more effect on the animals that live in this environment than on those that live above the snow (Halfpenny & Ozanne 1989).

Light penetration to plants under the snow may initiate plant growth and seed germination late in the winter, thereby providing a food source for mammals. Consumption of plants with phenolic compounds (which are found in growing grasses and other plants) is possibly a cue for the initiation of the reproduction process in some mammals (Halfpenny & Ozanne 1989). Carbon dioxide may accumulate in varying levels of concentration under the snow. Higher concentrations of carbon dioxide may affect the physiological functions of plants and animals, possibly resulting in the reduced ability of subnivean animals to find food or avoid predators (Halfpenny & Ozanne 1989). Water running through snowpack can cause flooding at ground level and below, and, especially during spring runoff, subnivean animals may drown or die of hypothermia (Halfpenny & Ozanne 1989).

Most research relating to the impacts of winter recreation on subnivean fauna has concerned the effects of snow compaction due to snowmobiles on the animals. One of the potential impacts of snow compaction is alteration of the snow microclimate, especially the physical and thermal aspects (Corbet 1970). Some of the possible changes in snow conditions resulting from snow compaction include a decrease in subnivean air space, a change in temperature, and accumulation of toxic air under the snow (Jarvinen and Schmid 1971, Schmid 1971a and b). Temperature changes may result in animal movements under the snow being limited, the suitability of a site for seed germination being reduced, and winter mortality of subnivean wildlife being increased (Keddy et al. 1979). There is a possibility that carbon dioxide could accumulate under the snow to levels that are toxic to small mammals. Carbon dioxide tends to flow downhill. If a compacted area is located at the bottom of a hill or even on a side slope, carbon dioxide accumulation could be fatal to the small mammals attempting to move through the area under the snow (H. Picton, Montana State University, personal communication).

According to Halfpenny & Ozanne (1989), skiers may do more damage to the snowpack than snowmobilers because narrow skis cut deeper into the snowpack and because skis have a greater footload (amount of weight per surface area) in comparison to a snowmobile track. For both ski tracks and snowmobile tracks, multiple passes over the same track will have more impact than a single pass. The larger the area of compaction, the greater the possible impact to subnivean fauna. If the habitat area is small, if rare species are present in the area, or if the activity is not restricted to narrow paths, impacts to subnivean life may be substantial and damaging (Halfpenny & Ozanne 1989).

Subnivean fauna in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(4) Groomed motorized routes
(5) Motorized routes
(7) Groomed nonmotorized areas

MANAGEMENT GUIDELINES

The lack of information about impacts to subnivean mammals from winter use makes it difficult to draw conclusions. However, there is the potential for an increase in winter mortality of these animals because of the impacts of snow compaction. Until more research is completed in this area, the only management guideline is to encourage more research on the subject, especially in areas where widespread and high intensity snowmobiling or skiing occurs near comparison control areas.

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BIRDS

Photo courtesy of the National Park Service

EFFECTS OF WINTER RECREATION ON BALD EAGLES

POPULATION STATUS AND TREND

Nesting, wintering, and migrating populations of bald eagles (*Haliaeetus leucocephalus*) occur in the Greater Yellowstone Area (GYA). Bald eagles are protected under the Migratory Bird Treaty Act of 1918 (16 U.S. Code 703) and the Bald Eagle Protection Act of 1940 (16 U.S. Code 668). Bald eagles were initially listed as an endangered species under the Endangered Species Act of 1973 (U.S. Code 1531, 1982 amended), but on July 12, 1995, the bald eagle's status was downlisted to threatened in the lower 48 states. This action did not alter those conservation measures already in place to protect the species and its habitats.

Because of the eagle's initial status as endangered, the Pacific States Bald Eagle Recovery Team was formed (the GYA is part of the Pacific Recovery Area). The team produced the Pacific Bald Eagle Recovery Plan (USFWS 1986), which addressed the recovery of bald eagles in Washington, Oregon, California, Nevada, Idaho, Montana, and Wyoming. Regionally, other teams were formed, and the Bald Eagle Management Plan for the Greater Yellowstone Ecosystem was issued in 1983 (revised 1996), and the Montana Bald Eagle Management Plan was issued in 1986 (revised 1994). Both plans identify threats to the bald eagle and provide management direction for population recovery in the respective areas.

Three population units were delineated in the GYA based on bald eagle natural history and the elevation, climate, and vegetation of the units (GYBEWG 1996). The Snake Unit includes bald eagle breeding areas associated with the Snake River in northwestern Wyoming and southeastern Idaho. The Continental Unit includes the watersheds in southwestern Montana, the upper Henrys Fork, southeastern Idaho, and northwestern Wyoming. The Yellowstone Unit includes most of Yellowstone National Park.

Between 1970 and 1995, the bald eagle population in the GYA increased exponentially. There were 111 known breeding areas in 1995 (GYBEWG 1996). Population growth has been attributed to the significant reduction of environmental contaminates, such as DDT (pesticide), and the initiation of intensive nesting surveys (Flath et al. 1991).

LIFE HISTORY

The average life span of a wild bald eagle is estimated to be between 10 and 18 years (MBEWG 1994). Bald eagles first breed at 6 to 7 years (Harmata and Oakleaf 1992) after adult plumage is acquired (Stalmaster 1987). Nest building most commonly occurs during the autumn, late winter, and early spring (October to April), although nest repair may occur during every season for well-established pairs. Alternate nests may be present in a breeding area. Incubation can begin as early as the first week of February and as late as the last week of March (Swensen et al. 1986, Harmata and Oakleaf 1992, Whitfield 1993, Stangl 1994) and lasts 35 days. Bald eagles are very sensitive to disturbance during nest building, egg laying, and incubation.

Bald eagles are opportunistic feeders and prey on fishes, waterfowl, lagamorphs, some ground-dwelling mammals, as well as ungulate carrion. Bald eagles also steal prey from other eagles, osprey, otters, and many other species (Stalmaster 1987, Harmata and Oakleaf 1992, Stangl 1994).

In the GYA, adult breeding pairs of eagles may or may not migrate out of the ecosystem during the winter (Harmata and Oakleaf 1992). Juvenile, immature, and adult eagles migrate at different times, therefore, age ratios of a population may differ during the winter. Juveniles migrate earlier in the autumn (Stalmaster 1987, Harmata and Oakleaf 1992) and may travel farther than sub-adults or adults (Stalmaster 1987). Band encounters and radio tracking of juvenile and immature bald eagles produced in the GYA indicated that virtually all birds leave the ecosystem in the first autumn after fledging. Juveniles return in mid-April to early May and appear to remain within the GYA during the summer. Juvenile eagles originating in Canada winter within the GYA.

HABITAT

WINTERING HABITAT

Bald eagle winter habitat is generally associated with areas of open water (unfrozen portions of lakes and free-flowing rivers) where fishes and/or waterfowl congregate (Swensen et al. 1986, Stalmaster 1987, GYBEWG 1996). Most winter habitats include major rivers and large lakes. Eagles will forage on high-quality foods away from aquatic areas, in particular, upland areas where ungulate carrion, game birds, and lagomorphs are available (Swenson et al. 1986). Ungulate carrion associated with late-season hunter harvests and big game wintering areas are also important to wintering bald eagles (GYBEWG 1996).

NESTING HABITAT

Nesting habitat varies among units in the GYA. Nest sites are generally distributed around the periphery of lakes, reservoirs, and along rivers. Nests are most commonly constructed in mature or old-growth stands of large diameter trees that are multi-layered and contain a variety of species, primarily Douglas fir (*Pseudotsuga menziesii*), black cottonwood (*Populus trichocarpa*), and spruce (*Picea* spp.). Large emergent trees and snags provide important nesting and perching habitat (Wright and Escano 1986). Bald eagles display strong fidelity to a breeding area and often to a specific nest.

An available prey base may be the most important factor determining nesting habitat suitability (Swensen et al. 1986, Harmata and Oakleaf 1992, MBEWG 1994), nesting density (Dzus and Gerrard 1993), and productivity (Hansen 1987) of bald eagles. Bald eagles usually nest as close to maximum foraging opportunities as possible, although human activity will be avoided (Harmata and Oakleaf 1992).

ROOSTING HABITAT

Like nesting and perching trees, roost trees are typically mature or old conifers or cottonwoods. Preferred roosting habitat includes a protected microclimate that provides shelter from harsh weather and is characterized by tall trees that extend above the forest canopy and by locations that provide clear views and open flight paths (Stalmaster 1987). Roost locations lie within the breeding territory during the breeding season. Bald eagles may roost in the nest or nest tree. As nestlings grow, the adults may roost farther away from the nest site (Stalmaster 1987).

In many areas, night communal roosts are important during the fall and winter months. Although winter roosting habitat is not necessarily close to water or in close proximity to food sources, the availability of an abundant source of food, of foraging perches, and of secure night-roost sites away from human activities are important habitat components (GYBEWG 1996, MBEWG 1994).

HUMAN ACTIVITIES

Bald eagles may be affected by a variety of recreational, research, resource, and urban development activities. Pesticides, poisoning, electrocution, vehicle collisions, and shooting have directly affected eagles. Various types of human activities that influence the environment have indirectly affected eagles (Mathisen 1968, Knight and Knight 1984, Stalmaster 1987, Buehler et al. 1991, McGarigal et al. 1991, Harmata and Oakleaf 1992).

Management concerns initially focused on permanent alterations of bald eagle habitat, such as cutting down nest trees. However, recent studies have demonstrated the importance of protecting eagle habitat from temporary human activities, such as recreation (Stalmaster and Newman 1978, Knight and Knight 1984, Knight et al. 1991, McGarigal et al. 1991, Harmata and Oakleaf 1992). Many recreational activities are focused on or around major water bodies where bald eagles nest, roost, or forage, thereby increasing the potential for eagle–human interactions.

Temporary human activities have been shown to influence the behavior of wintering bald eagles (Stalmaster and Newman 1978, Knight and Knight 1984) and those in breeding areas (McGarigal et al. 1991, Harmata and Oakleaf 1992, Stangl 1994). Anthony et al. (1995) believe that the cumulative effects of recreational activities can have deleterious effects on eagle populations through reductions in survival, especially during the winter, and in reduced reproductive success (Montolopi and Anderson 1991).

POTENTIAL EFFECTS

Bald eagles are generally food-stressed during winter. High levels of human activity can potentially increase energy demands on wintering bald eagles and result in increased mortality rates (Stalmaster and Gessaman 1984). Juvenile bald eagles have higher energy demands, are less efficient foragers, and spend more time trying to acquire food than adults. Therefore, they are more likely to be adversely impacted by human activities.

During the breeding season, bald eagles are most sensitive to human activities during nest building, egg-laying, and incubation (February 1 to May 30). Human activities during this time may cause nest abandonment. After young have hatched, a breeding pair is less likely to abandon the nest. However, eagles may leave the nest due to prolonged disturbances, exposing young to predation and adverse weather conditions (MBEWG 1994, GYBEWG 1996).

Bald eagle responses to human activities generally range from displacement to avoidance of the human activity to reproductive failure. Bald eagle responses also vary depending on type, intensity, duration, timing, predictability, and location of the human activity. Responses may be influenced by the presence of another eagle nearby, the eagle's physical and behavioral state, the nature of the human activity, and the time and location of the encounter (Anthony et al. 1995). Eagle responses to human activities may differ with populations (Fraser et al. 1985) and with individual pairs (Stangl 1994). Some bald eagles may habituate to human presence and become more tolerant of human activities (Knight and Knight 1984, Harmata and Oakleaf 1992, GYBEWG 1996).

Human activities during the winter and spring can reduce feeding activities of bald eagles (Skagen 1980). These activities can also displace eagles from foraging areas (Stalmaster and Newman 1978), alter use patterns (*i.e.*, eagles will avoid a feeding area for a period of time), or shift spatial- or temporal-use patterns (McGarigal et al. 1991, Harmata and Oakleaf 1992, Stangl 1994, Smith 1988).

Vehicular activities along prescribed routes or within strict spatial limits and at relatively predictable frequencies are least disturbing to bald eagles (McGarigal et al. 1991, Stangl 1994, GYBEWG 1996). However, slow-moving motor vehicles can disrupt eagle activities more than fast-moving motor vehicles (McGarigal et al. 1991). Snowmobiles may be especially disturbing, probably due to associated random movement, loud noise, and operators who are generally exposed (Walter and Garret 1981).

Bald eagles have been displaced by pedestrian activities (Stalmaster and Newman 1978, McGarigal et al. 1991, Stangl 1994) especially when the activities occur outside of predictable use areas (Harmata and Oakleaf 1992). Grubb and King (1991) found that pedestrians (hikers, anglers, and hunters) were the most disruptive type of human activities to bald eagles. Stangl (1994) found that a bald eagle pair used perches that were spatially separated from pedestrian angler activities. Bald eagles that forage on the ground are most sensitive to human activities (Stalmaster and Newman 1978, Knight and Knight 1984, McGarigal et al. 1991), therefore, human disturbances may have a greater impact on eagles foraging on fish or ungulate carcasses (Anthony et al. 1995).

Riparian habitat is an important component of bald eagle habitat. Recreational impacts on riparian areas, specifically impacts to cottonwood trees, could affect bald eagle perch habitat as well as availability of prey.

In the GYA, winter recreational activities that are most likely to affect wintering, migrating, and spring nesting bald eagles include: snowcoach and snowmobile traffic, cross-country skiing, telemark skiing, snowshoeing, dog sledding, late-season elk hunting, and antler collecting. (Bison management activities also have the potential to impact bald eagles.) Groomed trails are often located in riparian areas, and activities on these trails can begin as early as October and extend as late or later than June. A review of the literature revealed that research has not been completed to assess the effects of snowmobile or other winter recreational activities on bald eagle wintering or breeding habitat, but some documents referenced potential effects of snowmobile activities (Shea 1973, Alt 1980, Harmata and Oakleaf 1992, Stangl 1994).

Bald eagles in the GYA are particularly affected by human use of the following Potential Opportunity Areas:

(1) Destination areas
(2) Primary transportation routes
(3) Scenic driving routes
(4) Groomed motorized routes
(5) Motorized routes
(6) Backcountry motorized areas
(7) Groomed nonmotorized routes
(8) Nonmotorized routes
(9) Backcountry nonmotorized areas
(10) Downhill sliding (nonmotorized)
(12) Low-snow recreation areas

MANAGEMENT GUIDELINES

The Bald Eagle Management Plan for the Greater Yellowstone Ecosystem (GYBEWG 1996) established a management goal “to maintain bald eagle populations in the GYA at high levels with high probabilities of persistence and in sufficient numbers to provide significance to the ecosystem, academic research, and readily accessible enjoyment by the recreational and residential public.”

Management of bald eagle winter and spring habitat should focus on the presence and abundance of food for eagles that is usually associated with open water, the availability and distribution of foraging perches, the availability of secure night roost sites, and freedom from human harassment (Martell 1992).

Adequate monitoring of bald eagle wintering and nesting populations is fundamental to effective management. Bald eagles may be "urban" or "rural" (GYBEWG 1996) and respond differently to recreation activities. Eagles in the vicinity of high human densities and recreational activities may become habituated to human presence and tolerant of certain human activities. Urban eagles may be exposed to human activities that increase gradually, usually within defined spatial limits, while human activities that rural eagles are exposed to are distributed and moving randomly at varying intensities and often seasonal and abrupt. In some winter recreation areas, eagles will initiate nest building while snowmobile activities are at their highest levels.

The plan (GYBEWG 1996) suggested management guidelines with regard to winter recreation activities, including:

1. Encourage and support research to identify and quantify use and location of seasonal concentrations of bald eagles.
2. Establish buffer zones of 1,300 feet around high-use foraging areas with temporal restrictions from sunset to 10:00 a.m. in areas of high human use or establish site-specific modifications based on research findings.
3. Diurnal perching areas may not always be associated with primary foraging area. If separate, buffer zones of 650 to 1,300 feet around concentrated or high-use perches should be imposed, dependent on exiting vegetative screening. Temporal restrictions should be consistent with seasonal residency. Removal of trees, especially snags greater than 2 feet in diameter that are within 100 horizontal feet or 1,300 feet in elevational rise of greater than 30 degrees from shoreline should be discouraged on private land and prohibited on federal land. Single trees in upland foraging areas devoid of elevated perch sites should be retained.
4. Areas of winter and early spring waterfowl concentrations are important to wintering and migrating eagles. Efforts to enhance existing wetlands and development of new ones should be supported.
5. Strive to maintain visual, temporal, and spatial integrity of the roost site in order to provide for short- and long-term use by bald eagles. Manage critical and vital roost sites temporally and spatially. Areas within 1,300 feet of critical and vital roosts should be closed. Human activity beyond 1,300 feet may be disruptive if above the roost site. In such cases, methods to provide visual screening from the roost site should be explored and based on site inspection and recommendations of biologists. Closures for autumn roosts should extend from 1 October to 1 January, for winter roosts from 15 October to 1 April, for vernal roosts from 1 March to 15 April or determined by actual residency patterns of local eagles. Alternative schemes towards these ends should be encouraged to accommodate human values.
6. Strive for similar protection of secondary sites because they may evolve into critical or vital roosts through succession, fire, wind, or other catastrophe.

Guidelines have been developed in the Bald Eagle Management Plan for the Greater Yellowstone Ecosystem (GYBEWG 1996) and the Montana Bald Eagle Management Plan (MBEWG 1994) to provide management direction for bald eagles where there is little information on areas actually used. The GYBEWG (1996, pages 22–25) defined three zones within bald eagle breeding areas to which these guidelines apply. Zone boundaries should be altered after intensive study of eagle activity and development of site specific management plans. Guidelines and recommendations for the completion of management plans focused on bald eagle habitat or breeding areas.

ZONE I—NEST SITE AREA

The area within a ¼-mile radius of active nest sites should be maintained to protect nest site characteristics, including snags, nest trees, perch trees, roost trees, and vegetative screening. Any disturbances should be eliminated.

1. Human activity should not exceed minimal levels during the period from first occupancy of the nest site until two weeks following fledging (approximately 1 February to 15 August). Minimal human activity levels include essentially no human activity with the following exceptions: (1) existing patterns of ranching and agriculture, (2) nesting surveys and banding by biologist experienced with eagles, and (3) river traffic as defined by the GYBEWG (1996, page 22). Light human activity levels should not be exceeded during the rest of the year. Light human activity levels allow for day use and low impact activities such as boating, fishing, and hiking but at low densities and frequencies. Activities which are excluded include concentrated use associated with recreation centers (*i.e.*, picnic areas, boat landings) and helicopters within 650 yards of the ground.
2. Habitat alterations should be restricted to projects specifically designed for maintaining or enhancing bald eagle habitat and conducted only during September through January.
3. Human activity restrictions for Zone I may be relaxed during years when a nest is not occupied. However, light human activity levels should not be exceeded and land-use patterns should not preclude a return to minimal activity levels.

ZONE II—PRIMARY USE AREA

This zone includes the area ¼- to ½-mile from active nest sites in the breeding area where it is assumed that 75 percent of activities (foraging, loafing, bathing, etc.) of a bald eagle breeding pair occur.

1. Light human activity levels should not be exceeded during the nesting season. Moderate levels should not be exceeded during other times in the year. Moderate human activity include light impact activity levels but intensity of such activities are not limited. A limited number of recreation centers designed to avoid eagle conflicts may be considered. Other activities such as construction should be designed to specifically avoid disturbance. Designing projects or land uses to avoid eagle conflicts requires the sufficient data to formulate a site-specific management plan.
2. Habitat alterations should be carefully designed and regulated to ensure that preferred nesting and foraging habitat are not degraded.
3. Developments that may increase human activity levels and use patterns should not be allowed.

ZONE III—HOME RANGE

This area includes all suitable foraging habitat within 2.5 miles of active nest sites. Areas within the 2.5 mile radius of the nest that do not include potential foraging habitat may be excluded. However, the zone will include a 1,300 foot buffer along foraging habitat where the zone has been reduced.

1. Human activities should not exceed moderate.

2. Projects that could potentially alter the habitat of forage species should be carefully designed to insure availability of prey is not degraded. Adequate design of such projects will require data from site-specific management plans.
3. Terrestrial habitat alterations should ensure important components are maintained. Major habitat alterations should be considered only if site-specific management plans are developed and only if the alterations are compatible with management plans.
4. Permanent developments that are suitable for human occupancy should be avoided.

Other developments that may increase human activity levels should be carefully designed to ensure that objectives would not be exceeded for all three management zones. For example, active nest sites or any nest sites in the breeding area that have been active in the last five years if the active nest has not been identified should be protected.

Elk harvests occur during the fall and winter, and antler collecting occurs during the spring in various areas of the GYA. Gut piles and carcasses resulting from hunting activities provide a valuable foraging resource for wintering, migrating, and breeding bald eagles. Although some activities associated with the late hunt could displace bald eagles, hunting activities are generally completed early in the nesting season and the forage resulting from the harvest is probably more beneficial to bald eagles than the potential for displacement. This is not the case with antler collectors or “horn hunters.” Horn hunting activities generally occur during the spring when bald eagles are nesting and are most sensitive to human disturbances. Dispersed activities associated with horn hunting could potentially impact nesting bald eagles if the activities occur around the nest site or in the primary foraging area.

During winter and spring months, many wildlife species congregate at lower elevations. In the GYA, elk and moose are commonly observed along roadways and are periodically observed along designated and groomed snowmobile trails. Natural mortalities and road kill animals provide a winter and spring source of food for bald eagles. However, eagles can, in turn, become road kill victims themselves when foraging on carcasses located next to roads. Carcasses on and along roads should be moved away from the road edge in an effort to protect bald eagles and other scavengers. Similar incidents can occur along railroads where deer, elk, moose, and antelope may concentrate (J. Naderman, Idaho Department of Fish and Game, personal communication). Because a large portion of the GYA lies within the grizzly bear recovery area, road kill and some natural mortality carcasses are removed and are no longer available as a food source in an effort to reduce bear–human conflicts.

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EFFECTS OF WINTER RECREATION ON TRUMPETER SWANS

POPULATION STATUS AND TREND

The trumpeter swan (*Cygnus buccinator*) is a species of special concern in Idaho (Category A) and Montana, and a Priority 1 species in Wyoming. In March 1989, the Idaho Chapter of the Wildlife Society petitioned the U.S. Fish and Wildlife Service to add the Greater Yellowstone Area (GYA) trumpeter swan population to the threatened species list, but the population was not listed. Concern over the dramatic decline in the GYA trumpeter swan population led to the establishment of the Greater Yellowstone Trumpeter Swan Working Group in 1997.

During the 1800s and early 1900s, commercial trade in swan skins and habitat destruction reduced trumpeter swan populations to a fraction of historic levels. The species neared extinction in the lower 48 states, and isolated areas of protected habitat were critical to the survival of wild trumpeter swans (Banko 1960). The discovery of swans in the Centennial Valley in the 1930s led to the eventual establishment of Red Rocks Lakes National Wildlife Refuge. Management efforts at the refuge, as well as in a few other areas, have helped maintain trumpeter swan numbers in recent decades (Banko 1960, USFWS 1996).

The GYA trumpeter swan population has fluctuated dramatically and declined in recent years to the levels of the 1940s. Areas inside and outside Yellowstone National Park provide habitat for both resident and migratory swans. One theory for the decline is that traditional migration patterns and knowledge of important winter and spring habitats were lost as the species neared extinction. Another theory is that the swan population never migrated out of the GYA in large numbers. As a result, virtually all of the breeding trumpeter swans of Canada and the Greater Yellowstone Area share the same high-elevation winter habitat in the GYA (T. McEneaney, Yellowstone National Park, personal communication).

More than 10,000 swans currently exist in the wild. The Pacific population, representing most of the wild swans, breeds in Alaska and winters along the Pacific Coast from Alaska south to Washington (Ehrlich et al. 1988, Gale 1989). The mid-continental population of approximately 300 birds winters in the GYA. About 55 percent of these birds are year-round residents; the remainder migrate north and spend the summer in Canada (Gale 1989).

Currently, the swan population in the GYA has exhibited declining productivity. In Yellowstone National Park, no cygnets were produced in 1996 or 1997. In 1995, two of eight nest attempts were successful in the park, and six cygnets were produced, but only two fledged. In 1994, five cygnets fledged (NPS 1996; T. McEneaney, Yellowstone National Park, personal communication).

Winter habitat in the GYA is shared by resident and non-resident swans. Winter is a critical time for swans in the GYA as they are are vulnerable to reduced flows of water, heavy ice formation, unusually severe winter weather, disease, and environmental pollution. During the winter of 1988–89, about 100 swans died on the Henrys Fork as a result of ice formation on the river, which was due to low water flow and unusually low temperatures (Gale 1989; T. McEneaney, Yellowstone National Park, personal communication).

LIFE HISTORY

Trumpeter swans begin breeding between 3 and 6 years of age (most commonly at 4 or 5 years). They return to their breeding territories between February and late May. Most pairs remain together year-round and bond for life. The female normally lays between 4–6 eggs and incubates them for 33–37 days. The young hatch around late June and are precocial (they are mobile, downy, follow parents, and find their own food). The time from hatching to fledging ranges from 91–119 days. Cygnets remain with their parents through their first winter (Ehrlich et al. 1989, Gale 1989).

Trumpeter swan winter habitat is associated with open water, especially along the Henrys Fork River and the thermally influenced waters of Yellowstone National Park. Winter habitat must provide extensive areas of ice-free open water where aquatic plants are available (Gale 1989, USFWS 1996, Banko 1960).

NESTING HABITAT

Breeding habitat is usually freshwater, especially the emergent vegetation on the margin of ponds, marshes, and lakes; however, brackish waters and slow-moving oxbows may be used. Nests are surrounded by water and built of aquatic and emergent vegetation, down, and feathers. Nests are often built on muskrat houses, beaver lodges, or small islands. Trumpeters generally use the same nest site for several years (Banko 1960).

Breeding territory in the GYA ranges from 25–37 acres and generally coincides with the size of the nesting lake. At Red Rocks Lakes National Wildlife Refuge in Montana, breeding territories average 32 acres. Breeding pairs exclude other trumpeter swans from their territories during the nesting and brooding period (USFWS 1996, Reel et al. 1989).

HUMAN ACTIVITIES

Swan tolerance for people varies by season and situation. Swans seem to be more tolerant of humans during the winter months, but display reduced tolerance as spring approaches, and they are preparing to migrate or breed (T. McEneaney, Yellowstone National Park, personal communication; Shea 1979). Observations by Shea (1979) indicated that swans on the Madison River showed more tolerance to winter recreationists than did swans on the Yellowstone River. Swans wintered on the Madison River within 55 yards of the road, which had heavy snowmobile traffic. Swans often retreated when visitors stopped, but continued to feed. Swans on the Yellowstone River generally reacted to recreationists by swimming farther out from shore (Shea 1979). Swans at Harriman State Park in Idaho had a more pronounced reaction to human disturbance; when approached by a person on skis or snowmobile, swans broke into flight, often moving several miles to another stretch of the river (Shea 1979).

POTENTIAL EFFECTS

Swan conservation efforts in the GYA focus on ensuring adequate stream flows and protecting and enhancing nesting and wintering habitat. Nesting and brood-rearing seasons are critical times for swan survival and production. Disturbance by humans can have negative effects on trumpeter swans and other waterfowl. Henson and Grant (1991) note that:

> . . . disturbance can affect productivity in a number of ways including nest abandonment, egg mortality due to exposure, increased predation of eggs and hatchlings, depressed feeding rates on wintering and staging grounds, and avoidance of otherwise suitable habitat.

In winter, problems occasionally arise when recreationists approach swans too closely. This kind of activity can lead swans to become habituated to humans, which may make them more prone to predation or roadkill. It can also lead to flushing swans from open water, resulting in increased energy requirements and a loss of energy reserves essential to surviving the winter and hatching and rearing young. The effect is exacerbated by the number of times a swan experiences disturbances.

Aune (1981) found that swans appeared to become habituated to moving snowmobiles, but that they fly or swim away upon approach by foot or ski or when a snowmobiler stopped. Aune noted that, in general, animals function best in a predictable environment. Groomed routes, both for snowmobilers and skiers, create a more predictable environment.

High cygnet mortality prior to fledging can to be related to the poor condition of nesting females following severe winters and/or late, cold springs. However, Maj (1983) found that mortality is more site- or pair-specific and not entirely related to the nutritional status of the laying female. Maj also noted that 130–190 days are required to lay an average clutch of five eggs, incubate the eggs to full term, and raise the cygnets to fledging. Limitations to breeding time may be an important factor in the GYA where only approximately 90 frost-free days occur each year. Drought conditions are also an important factor in cygnet mortality.

Trumpeter swans in the GYA are particularly affected by human use of the following Potential Opportunity Areas as well as any opportunity area that has open water:

(1) Destination areas
(4) Groomed motorized routes
(5) Motorized routes
(6) Backcountry motorized areas
(7) Groomed nonmotorized routes
(8) Nonmotorized routes
(9) Backcountry nonmotorized areas
(12) Low-snow recreation area

MANAGEMENT GUIDELINES

- Designating snowmobile and ski trails away from open waters used as winter habitat by swans can mitigate winter recreational impacts on the birds.
- Special restrictions may need to be implemented on open-water snowmobiling in areas that swans routinely use for feeding. These measures would reduce the energetic expenditures resulting from disturbance.
- Some concern has been raised about the effects of snowmobile noise on swans. At this time, no information is available on this subject.

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HABITAT

Photo courtesy of the National Park Service

EFFECTS OF WINTER RECREATION ON VEGETATION

Snowmobile, snowcoach, cross-country and telemark ski, snowshoe, and dog-sled activities occur throughout the winter and spring in the Greater Yellowstone Area (GYA). These activities occur on designated and/or groomed trails or as dispersed activities. Snowmobile activities often occur on constructed dirt and paved roadbeds. However, damage to vegetation has been observed in the GYA that is caused by winter recreational activities that occur off-trail. For example, branches of willows (*Salix* spp.) and sagebrush (*Artemisia* spp.) have been broken, and leaders have been removed from conifers.

POTENTIAL EFFECTS

There is little information available describing the ecological effects of snowmobiling and other winter recreational activities on vegetation. Research cited was completed in the 1970s and focused on assessing the impacts of snowmobile use on vegetation and snow characteristics in Minnesota and Canada.

SNOW COMPACTION

Snowmobile activities create trails as the vehicle compacts the snow. Other winter recreation activities also have the potential to increase snow compaction depending on the intensity of the activities. One traverse over undisturbed snow cover can affect the physical environment as well as damage plants (Wanek 1971). Compacted snow was calculated to have two to three times more density than uncompacted snow in Canada. Thermal conductivity of compacted snow was 11.7 times greater than uncompacted snow (Neumann and Merriam 1972).

SOIL TEMPERATURES

Soil temperature can also be affected by snowmobile compaction of snow. Wanek (1971, 1973) and Wanek and Schumacher (1975) observed that surface soil temperature under compacted snow was erratic and constantly lower than under uncompacted snow. Soils in the areas where snowmobiles traveled thawed later than where snowmobiles did not travel (Wanek and Schumacher 1975). This resulted in subsequent deep freezing that could affect the survival of many vegetative species. Wanek and Schumacher (1975) found that a large number of perennial herbs having subterranean organisms were subject to intracellular ice crystals which caused tissue dehydration. Soil bacteria, essential to the plant food cycle, were reduced 100-fold beneath a snowmobile track (Wanek 1971, 1973).

VEGETATION

Snowmobile activities damage vegetation on and along trails and in dispersed sites. The most commonly observed effect from snowmobiles was the physical damage to shrubs, saplings, and other vegetation (Neumann and Merriam 1972, Wanek 1971, Wanek and Schumacher 1975). Neumann and Merriam (1972) observed that compacted snow conditions caused twigs and branches to bend sharply and break. Stems that were more pliable bent and sprang back although the snowmobile track often removed bark from the stems' upper surfaces. Neumann and Merriam (1972) found that rigid woody stems up to one inch in diameter were very susceptible to damage. Stems were snapped off in surface-packed or crusted snow.

Snowmobiles often run over trees and shrubs tearing the bark, ripping off branches, or topping trees. In some trembling aspen (*Populus tremuloides*) areas, populations increased after snowmobiles disturbance. Deciduous trees that sucker may increase at first but then may decline if snowmobile activities remove the sucker shoots for several successive years (Wanek and Schumacher 1975). Studies (Neumann and Merriam 1972; Wanek 1971, 1973) indicated that conifers differed in tolerance of snowmobile traffic, and that pine species (*e.g., Pinus contorta*) were less susceptible to damage than spruce species (*e.g., Picea glauca*). Wanek and Schumacher (1975) found that young conifers were severely damaged by minimal snowmobile traffic. Depth of snow accumulation was the greatest factor contributing to snowmobile damage to conifers. Deeper snow tended to protect some species and age classes.

Herbaceous and woody plants exhibited varying responses to snowmobile activities. Most species were vulnerable to physical damage by snowmobiles. Twigs and branches of shrubby cinquefoil (*Potentilla fruticosa*) were broken more readily than aspen and buffalo berry (*Elaeagnus canadensis*). Some species increased while others decreased in number. Masyk (1973) found that productivity of grasses may be reduced in areas of snowmobile use. Wanek and Schumacher (1975) found that snowmobile activities set back the growth of some fast growing trees that normally would shade out some shrub species. Therefore, heliophytic shrubs proliferated.

In bog communities, snowmobile activities can result in frost penetrating more deeply, thereby delaying the spring thaw. Herbs and shrubs in these areas may exhibit population declines. Bog shrubs are highly susceptible to physical damage (Wanek 1973).

Early spring growth of some species may be retarded or may not grow under a snowmobile trail. This could potentially reduce the diversity of plants species available and/or reduce the quantity of available forage and the duration of forage availability for wildlife during the spring.

EROSION

Snowmobile activities may indirectly contribute to erosion of trails and steep slopes. If steep slopes are intensively used, snow may be removed and the ground surface exposed to extreme weather conditions and increased erosion by continued snowmobile traffic. The same results could occur when snowmobiles use exposed southern exposures. Because compacted snow generally takes longer to melt, trails are often wet and soft when the surrounding areas are dry. Consequently, these trails are susceptible to damage by other users during the spring (Masyk 1973).

In the GYA, the Potential Opportunity Areas in which vegetation is most affected include:

(4) Groomed motorized routes
(5) Motorized routes
(6) Backcountry motorized areas
(7) Groomed nonmotorized routes
(8) Nonmotorized routes
(9) Backcountry nonmotorized areas
(10) Downhill sliding (nonmotorized)

MANAGEMENT GUIDELINES

Adverse effects to vegetation are the result of cumulative factors. The impact of snowmobile activities on the physical environment varies with winter severity, the depth of snow accumulation, the intensity of snowmobile traffic, and the susceptibility of the organism to injury (Wanek 1973). Activities occurring on roadbeds and (most likely) trails are probably having little affect on vegetation as the areas are already compacted or disturbed. Effects of snowmobile activities on off-trail vegetation should be assessed at a landscape level.

Management or restriction of snowmobile activities should be considered in areas where forest regeneration is being encouraged as deformation of growth patterns was observed in conifers where leaders had been removed by snowmobile activities (Neumann and Merriam 1972). Management or restrictions should also be considered in fragile or unique communities, such as riparian and wetland habitats, thermal areas, sensitive plant species habitat, and areas of important wildlife habitat, in order to preserve these habitats.

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ISSUES

Photo courtesy of the National Park Service

EFFECTS OF DEVELOPMENT ON WILDLIFE

Increasing human development has a variety of impacts on wildlife and their habitats. The effects of development may act as additional adverse impacts to wildlife populations already affected by human activity. This may be important during winter when many wildlife populations are already nutritionally and energetically stressed.

The term "development" is most frequently used in reference to new home-building: subdivisions, ranchettes, and second homes. While this activity is possibly the most important factor affecting western wildlife, other types of development impact wildlife and habitats as well. For example, conversion of former wildlife habitat to agricultural use or livestock grazing land where wildlife is excluded and the construction of new roads or the expansion of existing road networks that create unsuitable habitats for wildlife are both types of development that may have important consequences for wildlife. Development, therefore, can be defined as any human activity that permanently reduces or removes habitat that is currently available to wildlife.

DEVELOPMENT IN THE GREATER YELLOWSTONE ECOSYSTEM

Although more than 80 percent of the Greater Yellowstone Area (GYA) is in public ownership, the approximately 20 percent of the area that is in private ownership (about 3 million acres) contains some of the area's most important wildlife habitats. These lands include ungulate winter ranges, riparian areas, and wetlands (Harting and Glick 1994). Since 1990, the region has experienced an overall growth rate of 12 percent, with some counties experiencing growth rates as high as 50 percent (Glick et al. 1991). As a result, home-building on rural private lands has increased tremendously (Glick et al. 1991), and nearly one-third of the region's private acres have been subdivided (Rasker and Glick 1994). As more people settle in the area, existing roads are increasingly unable to accommodate the larger volumes of traffic, and roads are often widened or new roads are built to link areas of development and use (Glick et al. 1998). The region's increasing population also contributes to increasing human use of the region's natural areas. For example, an estimated 25 percent of all visitors to Yellowstone National Park in 1990 were residents of the surrounding three states (National Park Service 1998).

GENERAL IMPACTS OF DEVELOPMENT ON WILDLIFE

DIRECT MORTALITY

Many human uses of developed landscapes are incompatible with wildlife use or presence and may result in direct mortality of wildlife that attempt to occupy those areas. Ungulates attempting to use historic winter range that has been converted to grazing land or agricultural use may not be tolerated because they compete with livestock for forage or cause damage to crops. Consequently, hunting seasons and/or areas may be designed to eliminate wildlife from those areas, or wildlife may be killed in special management actions. Large carnivores, such as bears and wolves, are generally not tolerated in proximity to areas of human habitation or use. Collisions with vehicles may also be a significant source of mortality for some wildlife populations. Between 1989 and 1995, an average of 117 wild animals were killed annually in vehicle collisions in Yellowstone National Park (Gunther et al. 1997). Severe winters may increase the number of road kills when wildlife seek lower elevation, low-snow areas, which are where roads tend to be built. Many animals also use roads and groomed trails as travel corridors when snow becomes deep and restricts movement. During the last ten years more than a dozen animals, including bison, coyotes, elk, and moose, have been killed in collisions with snowmobiles in Yellowstone National Park (M. Biel, Yellowstone National Park, personal communication).

REDUCTION OR ELIMINATION OF WINTER RANGE

Most ungulate species in the Rocky Mountain West rely on distinct summer and winter ranges, taking advantage of seasonally available forage at higher elevations during the summer and returning to areas of lower snow accumulation during the winter where there is greater access to forage. These low-elevation winter ranges, however, tend also to be favored by humans for settlement, agriculture, and road-building (Glick et al. 1998). Human occupation of winter home ranges may lead to decreased reproduction or increased mortality of ungulates that traditionally use those areas by decreasing the amount or quality of forage or by increasing disturbance levels (Mackie and Pac 1980, Houston 1982, Smith and Robbins 1994). Because ungulates tend to concentrate in areas of limited size during the winter, loss or degradation of even small portions of winter range have consequences far greater than loss of similarly sized portions of summer range (Mackie and Pac 1980).

FRAGMENTATION OF HABITATS AND POPULATIONS

Development frequently has the effect of fragmenting formerly large or widespread populations into smaller sub-populations isolated from one another to varying degrees. Fragmentation may also mean that connections to supplemental habitats or seasonal ranges are degraded or lost (Wilcove et al. 1986, Dunning et al. 1992). The ability of individuals to recolonize areas or supplement declining populations may be lost when habitat connections between sub-populations are degraded or severed (Wilcove et al. 1986). Because of these factors, populations in isolated natural areas tend to be small (Wilcove et al. 1986, Dunning et al. 1992). Small population size and lack of habitat options generally result in a lowered ability to withstand disturbance or natural environmental fluctuations and can result in local extinction of wildlife populations (Wilcove et al. 1986).

DISTURBANCE

Increasing numbers of humans present in the region have meant an increasing amount of human activity in areas used by wildlife. Human activity may prevent some wildlife species from taking advantage of foraging opportunities within their home ranges, even where habitats remain intact. Green (1994), for example, found that roads and traffic in Yellowstone may diminish or prevent bear use of some winter-killed ungulate carcasses. Disturbance that occurs in winter or other periods of energetic stress can be of particular concern. During the winter, many animals reduce their activity, and therefore energy expenditure, to compensate for reduced energy intake, a result of limited quantity and quality of available forage (Telfer and Kelsall 1984). Aune (1981) found that elk, bison, mule deer, and moose in Yellowstone National Park developed crepuscular activity patterns and showed altered patterns of movement and habitat use in response to winter recreationists. Behavioral and physiological responses to continuing harassment in the form of noise or certain types of human presence can shift an animal's energy balance so that more is expended than is taken in, which results in decreased survival or reproduction success (Anderson 1995).

OTHER IMPACTS

In addition to the examples listed above, development can have a variety of other impacts on wildlife. Subdivisions, agricultural areas, clearcuts, or roads can block migration or movement routes, resulting in the inability of animals to reach important habitat components such as breeding or nesting areas, seasonally available forage, or refuges from predation or disturbance (Wilcove et al. 1986, Dunning et al. 1992). Development can alter habitats making them more favorable for generalist species that out-compete specialists in their former habitats. White-tailed deer, for example, appear to be replacing mule deer near developed areas in the Gallatin Valley (Vogel 1989). Although attempts have been made in recent years to restore the role of fire in natural areas, the presence of nearby human developments means that fire suppression will continue on large portions of many protected areas. Long-term fire suppression leads to changes in vegetation, which may impact wildlife in diverse ways (Houston 1982). Ground disturbance by humans has increased the presence and distribution of various species of exotic vegetation that may out-compete important native forage species. Cheatgrass (*Bromus tectorum*), for example, has invaded large portions of western rangelands. While this species greens early and may be of some spring forage value to ungulates, it may ultimately reduce the availability of winter forage by out-competing other, later maturing species (Houston 1982).

IMPACTS TO INDIVIDUAL SPECIES

ELK

Humans are increasingly occupying elk winter range in the GYA. In the Jackson Hole area in the early part of this century, human occupation of elk winter range contributed to the death by starvation of thousands of elk in the valley (Anderson 1958, Robbins et al. 1982). Actions taken to mitigate for human usurpation of winter range, however, have created other problems and led to complex management issues requiring often controversial solutions.

In 1912 Congress set aside a portion of the remaining valley bottom as the National Elk Refuge, and in the 1950s winter feeding of elk on the refuge and on other state-run feedgrounds in Wyoming became policy (Anderson 1958). Because the available winter range is restricted in size and the feeding program was designed to maintain a relatively high elk population, a sometimes controversial hunting program designed to control the size of the elk population was necessary (Smith and Robbins 1994). Maintaining a large number of elk in a geographically restricted area has also contributed to the continued presence of brucellosis in the herd (Thorne et al. 1991). Brucellosis in cattle has been the subject of an intensive state and federal eradication program, and the presence of the *Brucella abortus* bacteria in wildlife in the GYA has been the subject of much controversy in recent years, complicating management of both bison and elk.

Elk in the northern portion of the GYA do not present such perplexing management problems, but are nevertheless faced with decreasing availability of winter range. Historical accounts indicate that large numbers of elk wintered in the Yellowstone River valley north of Gardiner, Montana, and summered in the mountain ranges north of the park (Houston 1982). Settlement and agricultural development in the valley bottom have reduced the number of elk that are year-round residents in this area to slightly more than 1,000 animals.

These animals winter along the margins of the valley (Houston 1982). In recent years, range expansion of the northern Yellowstone elk herd during the winter has been of some concern to wildlife and land managers (T. Lemke, Montana Fish, Wildlife and Parks, personal communication) and private landowners. During some winters, elk use both public and private lands designated for summer livestock grazing, lessening the forage available to cattle. In severe winters, elk often depredate winter hay stores on private lands in the valley bottom. Any factors decreasing the quality or availability of the winter range on public lands and protected areas will only increase the magnitude of these problems and increase pressures on the elk population.

BISON

Bison management in the GYA has been the subject of major controversy, largely because both the Yellowstone and the Jackson bison herds have been exposed to brucellosis. Brucellosis is a disease of cattle that has been the subject of an intensive state and federal eradication program since the 1930s. Because neither Yellowstone nor Grand Teton national parks encompass a complete ecosystem for most ungulates, including bison (Keiter 1991), animals migrate out of the parks in the winter. Historically, during severe winters, Yellowstone bison probably migrated to lower elevation winter ranges in the Yellowstone River valley north of the park (Meagher 1973) and, possibly, also to winter ranges in the Madison Valley. The bison population in Yellowstone was driven to near-extinction by the beginning of the twentieth century (Meagher 1973), and during the subsequent decades when the population was recovering and heavily managed, most of the historic winter range outside the park boundary was settled and developed by humans. Much of the land adjacent to the parks is used for cattle grazing and ranching for all or part of the year. Because of the concern that infected or exposed bison could transmit brucellosis to cattle (Thorne et al. 1991) and because bison may compete with cattle for forage or destroy fences or other private property, a very complex and controversial set of management plans and policies have evolved for Yellowstone's bison.

Bison from Grand Teton National Park migrate to the National Elk Refuge and take advantage of the winter feed provided for elk. Both elk and bison on the refuge have been exposed to brucellosis, and concerns exist regarding potential contact between bison and nearby cattle (Thorne et al. 1991). The result, as in Yellowstone, is a controversial management scenario that continues to be the subject of debate and discussion.

MULE DEER

Mule deer populations in portions of the GYA have declined dramatically in recent years, and human development on winter range may be a contributing factor. Mule deer numbers declined as subdivisions and human activity increased on historic winter range northeast of Bozeman, Montana (Mackie and Pac 1980, Vogel 1989). Individual mule deer, particularly adult does, exhibit a high degree of fidelity to the same seasonal home ranges (Garrott et al. 1987, Mackie and Pac 1980). Because of this, it has been estimated that loss of one square mile of primary winter range along the foothills of the Bridger Range could result in loss of up to 30 percent of the southern Bridger Range mule deer population (Mackie and Pac 1980). Disturbance associated with increased housing development may cause deer to become more nocturnal (Vogel 1989, Dasmann and Taber 1956). This shift in activity pattern could increase energetic demands on deer and other animals during winter when they are nutritionally and energetically stressed by causing them to forage during colder and more severe nighttime weather (Aune 1981, Vogel 1989).

Impacts may differ between migratory and resident herds. Nicholson et al. (1997) found that migratory mule deer are much more vulnerable to human disturbance than are resident animals. This may have serious implications for other migratory ungulates as well, including elk that migrate in and out of Yellowstone and Grand Teton national parks.

PRONGHORN

The northern Yellowstone pronghorn herd, at present numbering roughly 250 animals, is a remnant of a population that historically occupied the Yellowstone River Valley between Gardiner and Livingston, Montana (Barmore 1980). This herd may have been contiguous with pronghorn populations farther east in Montana. Pronghorn were eliminated south of Livingston prior to 1920 (Skinner 1922, Nelson 1925). Consequently, the Yellowstone pronghorn population is isolated. It is estimated that the herd has approximately 18 percent chance of extinction in the next 100 years (Goodman 1996) because of its small size and complete isolation from other pronghorn populations. Currently, pronghorn in Yellowstone have limited access to private lands north of the park boundary and, therefore, little buffer against severe conditions that occur at times within the park. Severely limited winter range may have contributed to a recent decline in numbers in this population.

The Jackson Hole segment of the Sublette Antelope Herd may be at risk from development. This population segment exhibits seasonal migrations from Grand Teton National Park south to Interstate 80 near Rock Springs, Wyoming. Oil and gas development on critical winter ranges of these antelope, coupled with increasing pressure on naturally restricted migration corridors, threatens such movement (Doug McWhirter, personal communication).

MID-SIZED CARNIVORES (MARTEN, LYNX, AND WOLVERINE)

Mid-sized carnivores, such as marten, lynx and wolverine, are particularly vulnerable to the effects of habitat fragmentation. The current presence and distribution of lynx and wolverine in the GYA is likely influenced by development and habitat fragmentation that is the result of logging and road-building. The patches of habitat remaining may not be of sufficient size to guarantee an adequate prey base to sustain populations of these species (Buskirk and Ruggiero 1994, Lyon et al. 1994). The quality of smaller habitat patches may also be degraded as a result of influences from edge species and other disturbances occurring at or near patch boundaries (Wilcove et al. 1986).

Marten, and to some extent lynx, require significant amounts of late successional stage (old-growth) forest components in their home ranges (Buskirk and Ruggiero 1994, Lyon et al. 1994). The appearance of early successional stage vegetation and structure in a mature forest that is a result of logging or subdivisions combined with easier access via summer roads or groomed snowmobile trails may increase the number of generalist predators, such as bobcats and coyotes, that compete with marten, lynx, and wolverine (Lyon et al. 1994). Dispersal and migration of marten may be largely dependent on the presence of heavily vegetated riparian areas or connected patches of mature forest (Lyon et al. 1994). Development of any kind may alter or remove these corridors, isolating populations, decreasing stability of the prey base (Buskirk and Ruggiero 1994), and increasing vulnerability to environmental pressures. Disturbance by humans is of concern during winter, when small prey that is utilized by martens may be less available because of snowcover (Buskirk and Ruggiero 1994). Woody debris allows marten to access prey beneath the snow surface (Buskirk and Ruggiero 1994), and its loss along with the compaction of snow by vehicles may have negative impacts on marten populations by decreasing available food.

LARGE CARNIVORES

Grizzly bears in the GYA are effectively isolated from other populations. Maintenance of a stable or increasing bear population depends solely on reproduction by resident females (Knight and Eberhardt 1985). Most grizzly bear deaths in the GYA between 1973 and 1985 were human caused (both legal and illegal) and were clustered around gateway communities or other developments near Yellowstone National Park. Various attractants such as garbage, orchards, and outfitter camps tend to draw bears into conflict situations with humans, frequently resulting in bear mortality (Herrero 1985, Knight et al. 1988). Developments can function as population sinks for bears and other animals, potentially creating a drain on already stressed populations.

Humans are responsible for most mortalities experienced by the newly reintroduced wolves in the GYA (Phillips and Smith 1997). Deaths occurred by collisions with vehicles, poaching, or management removals following wolf depredation on domestic livestock. Development on the borders of Yellowstone puts wolves in jeopardy if they travel outside of protected areas.

Factors that stress ungulate populations, and thus increase their vulnerability to predation or other types of mortality, may benefit large carnivores and scavenger species in the short-term. However, if such factors lead to a long-term reduction of the ungulate populations, carnivore and scavenger species may be adversely affected through a reduction in the total amount of prey or carrion biomass available to them.

OTHER SPECIES

Little is known about the several owl species inhabiting this region (Holt and Hillis 1987), but owls may be particularly vulnerable to disturbance during winter when prey species are less vulnerable due to snowcover. Guth (1978) found that bird density and diversity increased in developed sites, but that the species present represented a greater percentage of common and widespread species; several rare forest species were absent. Amphibians, reptiles, small mammals, and fish are likely to be affected indirectly and more subtly by development and recreation than large mammal species (Cole and Landres 1995). Impacts to these smaller species, however, may have long-term impacts to overall wildlife community structure and function by altering prey base, plant community dynamics, and animal distribution (Gutzwiller 1995).

MANAGEMENT GUIDELINES

It has been stated that a critical role of parks and other protected natural areas is to compensate or correct for the influence of modern man on ecosystem processes (Houston 1982). Few wildlife populations in the GYA are restricted entirely to protected areas (Keiter 1991), however, and protected areas are also subject to pressures accompanying development. Many effects of development, such as removing winter range, blocking migration routes, disturbance caused by human activity, and reducing quantity or quality of forage species, carry particular impacts during the winter when animals are nutritionally and energetically stressed. In view of these observations, the following recommendations may help to reduce or mitigate the impacts of development on wildlife:

- Minimize future development and, where possible, reduce current levels of development and their concomitant impacts in natural and protected areas.
- Place any necessary new developments within or immediately adjacent to existing developments so that human impacts are clustered, allowing larger portions of relatively pristine habitat to remain intact. The location of future and existing activities and developments should be carefully considered to avoid disturbing or removing important habitat components.
- Intrusive, noisy, or otherwise potentially disturbance-causing human activities should be avoided during the times of year when wildlife populations are already under severe environmental and/or physiological stress. Winter is a critical stress period for ungulates, and birthing/nesting time is critical for a wide variety of species.
- Cooperation among adjoining land management agencies and with landowners adjacent to protected areas should be strengthened so that habitats spanning more than one jurisdiction are managed or conserved as intact systems.
- Where possible, ungulate winter range should be protected or access acquired for wildlife to mitigate for existing development levels.
- Research and monitoring programs on a wide variety of species are vital to accomplishing most of the recommendations above. Information on seasonal habitats, migration routes, nesting or birthing sites and areas, and timing of animal activities are necessary in order to avoid significant impacts of development on wildlife populations.

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ENERGETIC COSTS OF WILDLIFE DISPLACEMENT BY WINTER RECREATIONISTS

Herbivores (plant-feeding animals) often function at an energy deficit during the winter months. Snow impairs their access to food, increases the energy cost of gathering the food, and increases the cost of locomotion. Because plant growth has stopped, except in thermal areas, the food value of plants is often low unless the animal has access to points of energy storage such as buds. Snow characteristics and depth are controlling influences upon the winter distribution of plant-feeding animals. In the northern Rocky Mountains, limited winter access to food has led to the selection of species that have an enhanced ability to store energy. This energy store provides a large proportion of the energy necessary to carry on animal functions through the winter. The rest of the energy must be gathered from winter range areas. A consequence of the limited energy stores and limited food availability is that disturbance of animals by winter recreationists may result in increased energy expenditure with adverse effects upon the survival of the animal, its ability to give birth to and raise viable offspring, and the maintenance of the social dynamics of the population. At the same time, winter recreation produces packed snow travel routes that may enhance energy conservation by the animals. Such trails include the single-file trails produced by the flight of animals disturbed by recreationists, cross-country ski and snowshoe trails, and groomed road and trail systems provided for snowmobile use.

To provide guidelines for the management of winter recreationists so that undue depletion of the energy supplies of Yellowstone herbivores can be avoided, it is necessary to analyze animal response to humans at the individual level and the group level. Factors that affect and induce variability in the responses of animals are discussed along with energetic implications.

MECHANISMS OF RESPONSE

SENSORY LINKS TO HUMAN INTRUSION

The response of animals to intruders begins with the sensory envelope of the animal. The major senses involved in this response are those of sight, olfaction, and hearing. Each of these senses has its own threshold, character, and pattern of response that may vary between the different species as well as between the different populations of each species. One of the concepts that is of use in understanding these responses is the Weber-Fechner law of psychosensory perception. This rule demonstrates that a sensory stimulus must change by a fixed proportion in order for an animal to recognize that the stimulus has changed. This is called the “just noticeable difference” (JND) or Weber-Fechner constant (Withers 1992, Randall et al. 1997). Some responses to these sensory stimuli, such as moving or changes in posture, have energetic implications. Other responses, such as changes in heart rate, may or may not have energetic implications. Bighorn sheep and elk respond to humans that approach to within 55 yards by increases in heart rate (MacArthur et al. 1979, Cassirer and Ables 1990). Because cardiac output is a function of the stroke volume of the ventricles as well as the heart rate, an increase in heart rate does not necessarily mean an increase in cardiac output nor does it always mean an increase in energy consumption (Ganong 1997).

Vision is a major sense for most animals, although it may be less important in relative terms to them than it is to humans. The JND for vision is typically about 0.14, meaning that stimuli must change by 14 percent in order for the change to be detected. The range at which wild, large mammals typically show some sort of avoidance or suppression of activities is typically about ½ to 1 mile in open, relatively flat terrain (Ward et al. 1973, Lyon et al. 1985, Cassirer and Ables 1990). This zone of visual interference of use is reduced at night and under conditions of vegetative cover density and height that block vision. An energetic implication of this is that use of the winter range in this zone of relative exclusion is reduced to about half its normal level (Lyon et al. 1985). Bighorn sheep, in some circumstances, tolerate closer intrusion, which is probably related to both the limited nature and greater security furnished by their rough and broken habitat. The habituation state of the animals also affects their response and will be discussed later. While partial color vision has been demonstrated in some non-primate mammals, it has not been conclusively demonstrated in most mammal species. (Experiments on color vision, properly controlling luminance, saturation, and brightness at all visible light wavelengths, are difficult to do and have not been accomplished for most park mammals.) Thus, color does not seem to be of importance in triggering energetically expensive behavior. It is believed that some species, such as bighorn sheep, have specializations for high acuity of vision, while other species excel at detecting movement. Breaking the visual stimulus by crossing a ridgeline or other visual barrier is an important factor in responses to disturbance (Dorrance et al. 1973, Lyons et al. 1985, Cassirer and Ables 1990) and, thus, can be a significant factor in regulating energy expenditure.

Smell or olfaction is an important sensory element for mammals. Odors can be carried some distance by air currents and may be absorbed on snow and vegetation. Olfactory sensing of chemical odors has a high JND (about 0.3) indicating that only fairly substantial changes in odor can be noted. The deposition of olfactants on snow and plants has the potential for extending sensory responses for considerable periods of time. Accommodation to odors occurs rapidly, and mammals do not appear to show avoidance of snowmobile pollution in the snow (Aune 1981). Thus, the persistence of snowmobile pollution does not seem to be an important factor affecting energetics. Accommodation to one odor does not necessarily mean suppression of the ability to detect others. Thus, the olfactants deposited by snowmobiles (Aune 1981) are unlikely to interfere with the detection of predators by odor. Sensitivity to individual odors varies widely and differs between species. While olfaction is an important communication pathway, it appears to be unimportant in triggering highly energetic behavior after the rut is over but, like hearing, may reinforce visual response (Cassirer and Ables 1990).

Hearing has a JND of about 0.15. While several studies (Dorrance et al. 1973; Ward 1977; MacArthur et al. 1979, 1982; Stockwell et al. 1991) have focused upon the effect of relatively loud noises on animal behavior, it is often the relationship of a sound to the background noise level that is significant. Vegetation is highly effective in absorbing sound (Aylor 1971a and b; Harrison 1978). The sound level from an idling pickup truck was measured at 50 db about 90 yards from the vehicle in an open environment and at 70 yards in a mature forest in the Yellowstone area (Anderson 1994). Sound levels of 45 to 65 db at the point of animal toleration have been reported for snowmobiles in some studies

(Bury 1978). Better muffling and design have reduced snowmobile noise levels since these studies were done. The berms of snow along groomed snowmobile trails also tend to absorb and deflect sound.

The channeling of sound by inversions and dense air layers is common in mountain environments. A sound that is not heard near its source may occasionally be carried and perceived ½ mile or more distant without having been heard at intermediate distances. Air currents are also important in conveying sound. Cassirer and Ables (1990) observed that wind blowing toward animals increases movement away, suggesting that smell and hearing tend to accentuate the response triggered by vision. Animals may be expected to show some response at sudden or erratic sounds of 1 to 3 db in the quiet 30 db environment of a forest while requiring higher sound energies to produce a response if they are in a 60 db environment along a busy road. Constant noise levels are readily accommodated for and, as mammal populations on jet airports and airbases (Weisenberger et al. 1996) demonstrate, even predictable loud sounds can be ignored by animals. However, unpredictable noise can affect range utilization and movements of elk (Picton et al. 1985).

INDIVIDUAL RESPONSE

The energetic response of individual animals to human intrusion varies widely. One question that arises in Yellowstone is: where on the wild to domesticated continuum do various subpopulations fall as habituation is a physiological process with energetic consequences. Are the elk within the limits of the Mammoth development wild or domesticated? If they are domesticated, no energetic cost of human presence is involved. The chronically elevated resting heart rates of these animals (Cassirer and Ables 1990) indicate that this subpopulation is habituated rather than domesticated. Habituation reduces the physiological cost of dealing with an environmental stressor, but it seldom eliminates the cost entirely. This habituation has involved learning to ignore the large auditory and olfactory stimulation imposed by human activities while learning to rely almost entirely upon sight. Visual responses have been modified to permit human intrusion as close as 16–22 yards without eliciting flight behavior.

In the absence of other data, we can use weight and heart rate comparisons between the Lamar and the Mammoth elk to make a minimum rough estimate of the energetic differences between the two areas (Cassirer and Ables 1990). It appears that the direct energy cost for habituation and its prolonged alert status that is required for daily living in Mammoth is about 2 percent more than the cost of living in the Lamar. However, the more accessible and better forage provided by the green lawns of Mammoth results in a net daily energy intake in the range of 6–7 percent more than that in the Lamar. This gives the Mammoth elk a net advantage of about 4.5 percent. Year-to-year variations in winter severity probably have more effect on the Lamar animals than on the Mammoth elk. If calf production differences are included, the net energetic advantage of the Mammoth elk might be as much as 8 percent per day during the fall and winter months. Because this is based upon fall calf/cow ratios, the effects of a higher predation rate upon the calves in the Lamar is not considered. This failure to consider differences in predation would tend to overestimate the energy difference between the two areas. It should be noted that biological variation suggests that not all individuals in a population habituate equally as well to humans, thus, we would expect a population to contain a segment that habituates easily and another segment that shows more extreme avoidance behavior.

The travel routes of humans, such as roads and heavily used trails, are usually avoided to some extent by animals. A rough estimate suggests that perhaps 10 percent of the northern Yellowstone winter range has had its large herbivore-use capacity reduced by 50 percent (Lyon et al. 1985) due to use of the northeast entrance road between Mammoth and Cooke City. This road is a permanent feature of the environment, but the effects of it can be seen in plots of animal distribution along the route. This implies a lost-opportunity cost of perhaps 5 percent of the total energy supply of the range. It is unlikely that this "highway" effect has reduced the capacity of the Gibbon–Firehole range to the same degree. The nature of the geothermal range, its topography, high habituation levels of animals, and the lower energy statuses of the animals tend to reduce some of these impacts.

The energetic effects of disturbance are affected by seasonal changes in the energy balance of the animals, snow conditions, and distribution as well as annual variation in the conditions. The usual pattern of energy regulation in animals is to expend the energy consumed in the last meal rather than to consume energy to replace the energy that has been expended since the last meal (Hainsworth 1981). Thus, as energy stores drop, the tendency to conserve energy increases (Moen 1976), which will lead to a decrease in flight initiation distances upon being disturbed. This is the general pattern seen in flight initiation distances during the course of a winter. Research should be conducted to determine if disturbance of the animals results in increases in the length or frequency of feeding bouts, which would suggest some replenishment of energy stores. If food intake does not increase, a more critical effect upon the animals is implied.

Early in the winter, snow conditions tend to be better under the forest canopy than out in the open. The cold winters of Yellowstone encourage the ablation of snow from the forest canopy to a unique degree (Skidmore et al. 1994). This process can prolong the use of forest cover by the ungulates, which reduces the intensity of auditory as well as visual disturbance and its energetic consequences. The group size of elk tends to be smaller in the timber and their flight distances shorter, which results in less disturbance impact.

It is clear that the energetic expenditures of animals must be considered on the basis of their habituation status and energetic status as well as on snow depth. Calculations were performed for each of three different range situations: the Mammoth habituated population, the Lamar population, and the Gibbon–Firehole population. Estimations were calculated for a 590 lb. adult elk, a 200 lb. calf elk, a 150 lb. adult mule deer, and a 1,200 lb. bison under both early winter snow conditions and the dense snow conditions of late winter. The daily activity budget of elk was used as the activity budget for all of the ungulates (Nelson and Leege 1982). A density of 0.2 was assumed for the early winter powder-snow conditions, and a density of 0.4 for late winter compacted snow. Comparative calculations were done for no snow and for snow depths of 30 percent and 58 percent of brisket height. These depths were selected on the basis of the knee (carpel) length (Telfer and Kelsall 1984). Energy expenditures go up at exponential rates when snow depths are above the knee, conditions that are generally not tolerated by the animals. Parameters concerning energy expenditure were obtained from Parker et al. (1984) and Wickstrom et al. (1984). Behavioral responses to disturbances were obtained from Aune (1981), Cassirer and Ables (1990), and Freddy et al. (1986). The energetic expenditure due to changes in the "alert" behavioral status of the elk was estimated using Cassirer and Able (1990). The percentages expressed are for a total estimated daily energy budget of 7,072 kcal. for a 590 lb. adult elk; 2,861 kcal. for a 200 lb. calf elk; 2,243 kcal. for a 150 lb. adult mule deer; and, 11,167 kcal. for a 1,200 lb. bison. The cost of a single flight for a habituated adult elk increased the 7,072 kcal. daily energy budget between 3.2 and 7.1 percent, depending upon snow conditions, for an escape distance of 0.3 mile. The longer escape distance of 1.2 miles reported for the Lamar area (Cassirer and Ables 1990) gave energetic increases of 8.7 to 24 percent on level terrain. If the elk in the Lamar runs uphill for 60 percent and downhill for 20 percent of the time over a typical escape course (Cassirer and Ables 1990), energy costs may increase by 40 percent over the cost estimated for level terrain. High single-escape costs of more than 10 percent probably could not be tolerated by the elk throughout the entire winter season. Behavioral adjustment would probably be made to use slopes with less snow, shorter escape distances, or habituation. What might be perceived as a greater tolerance of the animals to disturbance as the winter season progresses might, in reality, be the result of these energy conservation responses as well as the influence of the lower energy status seen in late winter. The much shorter escape distances reported for the Firehole area may be reflective of the much more marginal energy status of these elk (Pils 1998) as well as habituation. The overall energy expenditure of the 200 lb. calf elk for the various situations averaged about 16.3 percent more than that of adults. The shorter legs of the calves dramatically increase escape costs in deep snow. The number of disturbances or close encounters necessary to produce habituation is unknown, but probably exceeds two per day. Habituation to cars or snowmobiles following highly predictable paths readily occurs. Habituation to the less predictable occurrence and movements of cross-country skiers and individuals on foot is a more difficult situation (Bury 1978, Schultz and Bailey 1978, Aune 1981, Ferguson and Keith 1982, Freddy et al. 1986).

For a habituated mule deer, the daily energetic expenditure of a single intrusive event is estimated to increase the daily energy budget of 2,861 kcal. by 2.5 to 5.9 percent. In the Lamar, responses increased energy expenditures 4.7 to 17 percent as compared to a range of increase of 1.8 to 2.2 percent for the Gibbon–Firehole area. The responses of mule deer were based upon the observations of Aune (1981) and Freddy et al. (1986).

Little information is available concerning the energetics of bison. Specific information concerning bison was obtained from Telfer and Kelsall (1984) and combined with general information covering large mammals in general (Parker et al. 1984, Wickstrom et al. 1984, Withers 1992). Personal observations suggest that bison are relatively unresponsive to human intrusion. Thus, the elk response data from the Gibbon–Firehole was used in the calculations. A single disturbance produces an increase in daily energy expenditure of 1.5 to 2.1 percent more than the 11,167 kcal. daily energy budget. The low, late-winter energy levels of bison may increase their tendency to allow close approach by humans and increase visitor hazards.

Failure to produce viable offspring has been suggested as a logical outcome of imposing high-energy disturbance stress upon animals. In an experimental situation, Yarmaloy et al. (1988) reported that it required direct targeting of a specific mule deer with a harassing all-terrain vehicle (ATV) repeated 15 times (averaging nine minutes each time) during October to induce reproductive disturbance. Deer not specifically targeted habituated to the ATVs with little apparent notice and suffered no reproductive consequences. No information is available to indicate the frequency of disturbance throughout the winter by recreationists or predators of individuals or individual groups of animals.

GROUP RESPONSE

"Single filing" is a major group response that affects the energetics of response to winter recreationists and the situations created by them. Single filing reduces the energy costs of travel through snow to a major degree. While the parameters of this type of movement have not been defined in the literature, unpublished field observations suggest that by the time the tenth animal passes along a trail, the energetic costs will be reduced to near the base level for locomotory activity. While short-distance flight movements are often individual, group movements will usually coalesce into single files for the longer travel distances, such as is seen in the Lamar area.

Of course, the single-file animal trails are not the only packed trails in the park. Wildlife will sometimes use foot trails as well as the groomed snowmobile trails to facilitate their movements. While cross-country ski trails or snowshoe trails are usually not attractive to the large mammals (Ferguson and Keith 1982), groomed or heavily used ski trails may be attractive to them.

The monthly average snow depths on the various portions of the Firehole–Madison winter ranges were from 6.5 to 10 inches in the severe winter of 1996–97 (Dawes 1998). In estimating energy consumption, let us assume travel through 18 inches of dense snow, which is about the maximum tolerated depth based upon the brisket height of an adult elk and is a slightly more extreme depth for the shorter legs of calf elk and bison. If we further assume that the usual daily activity budget of an ungulate involves 0.6 mile of travel, we can calculate that an adult bison will save about 4.3 percent of a normal daily energy budget by using the groomed roads. At snow depths of 9.5 inches, more comparable to that seen on the winter range, the savings during the December through March deep-snow period would be about 1.2 percent of the daily energy budget or an accumulated 1.4 days for the normal 11,167 kcal. daily energy budget. If we postulate a 22-mile migratory movement from the Fountain Flat area to West Yellowstone through 18 inches of dense snow, the groomed trail savings will be the equivalent of 1.66 days of the normal energy budget for a 1,200 lb. bison.

An adult elk has a smaller body size and longer legs than a bison. The daily savings for an elk under deep, dense snow conditions is estimated at 3.4 percent of the daily energy budget and 1 percent for the more normal snow conditions of 9.5 inches. The savings under the 18-inch, dense snow conditions would be about 1.2 days worth of energy, assuming the conditions persisted for the 121-day December through March period or 47 percent of the cost of maintaining a pregnancy from conception to the end of March. A 22-mile migration over a groomed trail would produce energy savings of about 1.1 days for the 7,072 kcal. daily energy budget equivalent under the deep, dense snow conditions. The energy savings experienced by the shorter limbed 200 lb. calf elk are estimated at 4.9 percent of the 2,861 kcal. daily energy budget for the 18-inch, dense snow conditions and 1.5 percent for the 9.5 inch snow levels. This is equivalent to a gain of about 1.8 days supply of energy for the 121-day winter period.

PREDATORS

The interaction, if any, between winter recreational disturbance of ungulates and predation is unknown. A range of effects, from enhancing predation effort by increasing energy depletion and sensory confusion in the ungulates to the use of humans as protective cover by ungulates, can be hypothesized. The medium to large predators in Yellowstone have lower foot loadings than the ungulates and, thus, can move over the snow much of the time. This serves to compensate for their shorter brisket heights. Although usually regarded as wilderness animals, wolverines will include clear-cut areas in their home ranges, and it has been speculated that later winter snowmobile use might affect habitat use (Hornocker and Hash 1981). Unpublished observations indicate that wolverines will use areas of terrain subjected to moderate uncontrolled snowmobile use (J. W. Williams, Montana Fish, Wildlife and Parks, personal communication). Wolves, foxes, coyotes, wolverines, and lynx are known to use roads and snowmobile and other trails when traveling (Neumann and Merriam 1972, International Wolf 1992, Ruggiero et al. 1994). The frequency of ungulate disturbance by either predators or humans is unknown. Avoidance of areas of intense human use by predators has also been reported.

MANAGEMENT GUIDELINES

- Make human use of wintering areas as predictable as possible. This can be done by restricting access and the timing of the access. Preferably, skiing should be restricted to mid-day hours and designated paths.
- Humans on foot should not approach wildlife, even those that are habituated, any closer than 20 yards; preferably, not closer than 55 yards.
- Escape breaks in the snow berms along plowed roads and groomed trails should be made to permit animals to easily leave the roadway. Crossing a deep snow berm often causes a brief but intense expenditure of energy. Animals in late winter condition may have considerable difficulty in producing the brief intense energy flow necessary to meet these demands.
- Any winter-use trails in close proximity (less than 700 yards) to major wildlife wintering areas should be screened by routing to put the trail behind ridgelines and vegetative cover.
- Low speed limits should be set on roads and snowmobile trails, particularly in winter range areas.
- Information, past and future, concerning snow depths, snowmobile use, and the reproductive ratios of each species and each major population segment should be collected and analyzed for indications of negative effects on wildlife.
- Information on the daily activity budgets and daily movement budgets of bison are lacking. This information could give considerable insight into the impacts of winter recreation upon this species and should be collected.
- Public information efforts concerning the winter ecology of animals should be conducted. Information concerning the actual frequency of disturbance is desirable for more definitive estimates of the energetic impacts resulting from winter recreationists. Information concerning the interaction of this disturbance with that produced by wolves is desirable.

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IMPACTS OF TWO-STROKE ENGINES ON AQUATIC RESOURCES

Human recreational activities impact aquatic resources directly and indirectly. Winter recreation affects aquatic organisms mainly by indirect impacts due to pollution. Two-stroke engines can deposit contaminants on snow, leading to ground and surface water quality degradation, which subsequently may impact aquatic life.

LIFE HISTORY AND STATUS

Fish are important components of aquatic ecosystems and are important links in the transfer of energy between aquatic and terrestrial environments. Native and non-native fish, aquatic microorganisms, insects, and crustaceans integrate into a complex aquatic community. In Yellowstone National Park there are 12 native and 6 introduced fish species (Varley and Schullery 1983). In the Yellowstone area and the Rocky Mountain region, trout and other salmonids (Family Salmonidae) are the major game species. Native fish include Yellowstone cutthroat trout (*Oncorynchus clarki bouvieri*), westslope cutthroat trout (*O. clarki lewisi*), Snake River cutthroat trout (*O. clarki*), arctic grayling (*Thymallus articusi*), mountain whitefish (*Prosopium williamsoni*), mountain sucker (*Catostomus platyrhnchus*), longnose sucker (*C. catostomus griseus*), Utah sucker (*C. ardens*), mottled sculpin (*Cottus bairdi*), redside shiner (*Richardsonius hydrophlox*), Utah chub (*Gila atraria*), longnose dace (*Rhinicthys cataractae*), and speckled dace (*R. osculus*). Non-native fish species include rainbow trout (*O. mykiss*), brown trout (*Salmo trutta*), eastern brook trout (*Salvelinus fontinalis*), lake trout (*S. namaycush*), and lake chub (*Couesius plumbeus*).

Some fish species are becoming endangered as populations decrease from human exploitation, environmental degradation, and competition and predation from exotic or introduced species. While no fish species in the Yellowstone area are listed under the Endangered Species Act, the fluvial Arctic grayling, westslope cutthroat trout, and Yellowstone cutthroat trout are considered species of concern in Wyoming, Montana, and Idaho. All three species have been petitioned for federal listing under the Endangered Species Act (50 CFR Part 17), and it has been determined that listing of the fluvial Arctic grayling as endangered is warranted but precluded at this time. Determinations for the other two species are pending.

HUMAN ACTIVITIES

Much of the existing literature relating to impacts on aquatic biota has been restricted to outboard engines on boats that discharge a variety of hydrocarbon compounds directly into the water column (Bannan 1997). However, the discharge of snow machine exhaust directly into accumulated snow may provide a corollary. For example, emissions from snowmobiles have been implicated in elevated lead contamination of snow along roadsides (Ferrin and Coltharp 1974). Although lead is no longer a concern, hydrocarbons are still deposited on the top layer of snow along snowmobile trails (Adams 1974).

Contaminants from two-cycle engine exhaust include carbon monoxide, hydrocarbons, Methyl-*tert*-butyl ether (MTBE), Nitrous oxides (NO_x), and particulate matter (White and Carrol 1998). Considerable variation exists among these compounds with respect to toxicity and persistence in water or aquatic sediments. Temperature and dilution rate (*i.e.*, mixing by propellers) appear to affect volatility (*e.g.*, evaporation rate) and long-term distribution of specific compounds. Because two-cycle engine exhaust contains numerous types of hydrocarbons, analyses typically focus on effects of only the more persistent types, particularly polycyclic aromatic hydrocarbons (PAH).

Studies of Lake Tahoe suggest that localized reductions of zooplankton populations may occur in areas of high boat usage. Deleterious effects can occur both in terms of mortality and histopathological response (Tahoe Research Group 1997). Extensive laboratory tests in Sweden documented that rainbow trout exposed to typical levels of engine exhaust could be negatively affected in growth rates, enzyme function, and immune responses (Balk et al. 1994). Also, sex-specific differences were observed, which could lead to alteration of normal reproductive function. MTBE is an oxygenated additive emitted from engine exhaust that is soluble in water and does not break down readily. However, no formal Environmental Protection Agency (EPA) drinking water standards are set for this compound. Nitrous oxides contain nitrogen, which can be a limiting nutrient in aquatic systems. It is considered a small risk because of its small percentage to total atmospheric deposition rates. However, it can contribute to eutrophication. As a result, some concerned investigators have recommended restrictions on the number of two-cycle engines allowed in high usage areas of Lake Tahoe (Tahoe Research Group 1997). Similar concerns have been voiced for Lake Michigan, Isle Royale National Park, and San Francisco Bay.

Under certain environmental conditions, toxicity of some PAH compounds may increase substantially. The toxicity of PAH can be “photo enhanced” in the presence of ultraviolet light (UV) and become 50,000 times more toxic under field conditions in the presence of sunlight. When PAH are in the bodies of aquatic organisms and absorb UV light, the energized molecules or their reactive intermediates can react with biomolecules to cause toxicity that can lead to death of aquatic organisms (Allred and Giesy 1985, Holst and Giesy 1989).

Impacts to aquatic species that can be attributed to atmospheric deposition from snowmobiles have not been well studied. Field studies are extremely difficult to conduct because atmospheric deposition rates could be affected by numerous factors, including temperature, proximity to water, and combustion efficiency of individual snowmobiles. One of the more extensive studies used caged brook trout to determine effects of exhaust on fish. Exhaust components taken up by fish correlated with levels present in the environment as a result of snowmobile use (Adams 1974). Uptake of exhaust hydrocarbons and other compounds occur through the gills during respiration. It is thought that hydrocarbons are incorporated into fatty tissues, such as visceral fat and the lateral line, in a manner similar to chlorinated hydrocarbon pesticides.

Tremendous uncertainty accompanies discussion of this topic with reference to affects on aquatic resources of the GYA. The current lack of quantitative data reduces comparisons between outboard engines and anticipated effects from a specific level of snowmobile use. However, it appears reasonable that higher concentrations from emissions will likely accumulate as a result of grooming roads with the constant packing of exposed snow. These accumulated pollutants will enter adjacent watersheds during the spring melt, which generally occurs from April through June. Pollutants entering the watershed will be concentrated during this snowmelt, producing a strong “pulse” in the system. Similarly, impacts from acid rain in the eastern United States are confounded by the accumulation of the acid in snow, with subsequent melting producing a pulse of acidity in a short time and causing very low pH in many streams (Carline et al. 1992, Haines 1981).

POTENTIAL EFFECTS

Protection of park aquatic resources and restoration of native species are primary management goals of the National Park Service. In Yellowstone National Park, groomed snowmobile roads are often adjacent to major aquatic systems (*e.g.*, Firehole River, Madison River, Gibbon River, Yellowstone River, Lewis River, and Yellowstone Lake). The Yellowstone River from the Yellowstone Lake outlet to the Upper Falls contains Yellowstone cutthroat trout. The Madison River is a potential reintroduction site for westslope cutthroat trout. The Gibbon and Madison rivers may contain fluvial Arctic grayling. Snowmobiling occurs on Hebgen, Jackson, and other small lakes located in the greater Yellowstone area. There are also areas where snowmobiles cross open water.

Hydrocarbon pollution in water may initially persist on the surface but will eventually settle into the water column, increasing exposure to fish and invertebrates. Investigations have shown dramatic increases in some contaminants in water exposed to snowmobile exhaust; some of these increases are on the order of 30 times (Adams 1974). Accumulation may also occur in sediments (Lazrus et al. 1970). Fish receive contamination from different trophic levels that are sustained in both open water and sediment environments. These pollutants accumulate in the food chain, and accumulations in fish would result in uptake by piscivorous predators including bald eagle, osprey, otter, pelican, and grizzly bear.

Physiological responses of fish to increased loads of hydrocarbons and other contaminants may increase direct and indirect mortality rates. Rainbow trout and cutthroat trout begin spawning in early spring (March through July), exposing developing embryos during this period. Research has shown that even at extremely low levels of hydrocarbon pollution, impacts may include chromosomal damage; retarded growth and development; disruption of normal biological functions, including reduced stamina for swimming and maintaining positions in streams (Adams 1974); and death.

Invertebrate vulnerability is not known; however, it is likely that early instar development may be impacted by hydrocarbon pollution entering the water. Many winter shredders (invertebrates that consume large organic debris) are emerging, mating, and laying eggs in early spring (*e.g.*, stoneflies). These developing embryos may, therefore, be more susceptible to pollutants during spring runoff periods.

Impacts of winter recreational activities on fish and other aquatic resources occur mostly where oversnow machines concentrate along groomed motorized routes and winter destination areas. In situations where snowmobiling occurs over open water (D. Trochta 1999), obvious impacts will include direct discharge into aquatic habitats. Appreciable contamination from emissions from backcountry snowmobiling probably occurs less frequently. However, dispersed snowmobile travel affects vegetation (J. T. Stangl 1999), causing erosion and damaging natural water courses and banks. Snowmobiles can cause degradation of stream and lake quality and affect aquatic species and their habitat.

Management of oversnow machine recreation should encourage the development of clean emission standards. Strict emission requirements for two-stroke engines would mitigate impacts to water quality and, subsequently, aquatic environments. Restricting motorized winter recreation near streams, lakes, and wetland habitats would minimize direct impacts to aquatic resources.

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EFFECTS OF WINTER RECREATION ON HABITUATED WILDLIFE

Little information exists on the direct and indirect impacts of winter recreation on most wildlife species. However, these effects may create potentially additive or synergistic impacts to wildlife populations (Knight and Cole 1995). Effects include energetic response to humans and human facilities, habituation to human activities, and attraction or conditioning to human foods and garbage (Herrero 1987).

Most wildlife species that become habituated or food conditioned from winter recreational activity are not protected under federal law. These include ungulate populations accustomed to winter recreationalists, roads, and snowmobile trails (Aune 1981, Meagher 1993), and carnivores, such as coyote, red fox, pine marten, that become food conditioned to human foods at recreational facilities. Bird species, including ravens, gray jays, and Clark's nutcrackers, also may become food conditioned and are protected under the Migratory Bird Treaty Act. Both black and grizzly bears have the potential to become habituated to human activities and food conditioned to human foods (Mattson 1990), but are typically not active during the winter season (Judd et al. 1986).

All wildlife species are protected in national parks (NPS 1988). On lands outside national parks, some wildlife species are subject to hunting. Most non-game bird species are protected from direct human-caused mortality by the Migratory Bird Treaty Act (U.S.C. Title 16, Section 703). Species in the Yellowstone area protected by the Endangered Species Act of 1973 (U.S.C. 1531, 1982 ammend.) include the whooping crane and peregrine falcon, which are endangered, and the bald eagle and grizzly bear, which are threatened. Whooping cranes and peregrine falcons are not considered winter residents of the Yellowstone area. Gray wolves were recently reintroduced to the Yellowstone area. While naturally occurring wolves are classified as endangered in Montana, Idaho, and Wyoming, those reintroduced into the Yellowstone and central Idaho ecosystems in 1995 and 1996 were reclassified as "experimental/non-essential populations" (USFWS 1994).

LIFE HISTORY

Many wildlife species are residents of the Yellowstone area during winter. Terrestrial species include bison, elk, mule deer, moose, bighorn sheep, mountain lion, lynx, bobcat, marten, fisher, river otter, wolverine, coyote, gray wolf, red fox, and snowshoe hare. Avian species include bald eagle, trumpeter swan, common raven, gray jay, Clark's nutcracker, great gray owl, waterfowl, raptors, and passerine bird species.

Many wildlife species migrate or become inactive during winter months. Others however, remain and adjust their foraging, habitat use, and activity patterns to winter conditions. While most winter animals are well adapted to surviving winter situations, winter environments typically create added stress to wildlife due to harsher climatic conditions and more limited foraging opportunities.

HUMAN ACTIVITIES

Winter recreation has the potential to affect wildlife foraging patterns, habitat use, and interaction with human activities. When winter recreation occurs, some wildlife species may become accustomed to people and, therefore, habituated to human activities. A further step in this process occurs when animals gain and then seek out human foods (Herrero 1985). Examples of the effect of wildlife habituation in winter recreational situations include:

1. Bison in Yellowstone National Park utilize groomed snowmobile roads as travel routes (Aune 1981, Meagher 1993).
2. Ravens converge at winter destination areas, such as developed areas and warming huts, and forage on human foods discarded or left unattended in snowmobile seat compartments and/or packs; this results in property damage.
3. Coyotes and red foxes frequent winter developments and warming huts to seek hand-outs from visitors or forage on improperly discarded food scraps. Some eventually display aggressive behavior, sometimes harming visitors. These animals are removed from the area or destroyed.
4. Areas of winter garbage storage inside and outside Yellowstone National Park attract an array of wildlife species including coyotes, red foxes, pine martens, red squirrels, ravens, magpies, and gray jays.

POTENTIAL EFFECTS

Very little information exists on specific effects of winter recreation on habituated wildlife. Moreover, the need for more specific scientific monitoring is essential to better understand the complexities of wildlife–human interactions and the direct and indirect effects that winter recreation create on wildlife populations. It is sometimes difficult to determine whether wildlife habituation can be an advantage or a detriment to populations. Studies have indicated a shorter flight distance and a higher tolerance for vehicles and humans as a result of habituation (Aune 1981, Gabrielson and Smith 1995). However, habituation can also lead to unnatural attraction to human-use areas and lead to direct management actions and subsequent human-caused mortality (Herrero 1985, Mattson 1990, Mattson et al. 1992).

Potential Opportunity Areas that will be particularly affected include:

(1) Destination areas. Highly developed destination areas may negatively impact wildlife where winter recreational sites occur in habitats that wildlife occupy. Winter destination areas are becoming more popular. These include major ski areas and park development areas, and park gateway communities. These can also be low or moderately used areas such as small residential communities and warming huts. Wildlife avoidance of habitats could occur near winter developments. However, the more obvious management concern arises when animals are attracted to developments in search of human foods.

In areas with strong bear management guidelines, such as Yellowstone National Park, a strong emphasis is placed on food storage and security (Gunther 1994). However, in winter when bears are hibernating, a lapse in food security appears more common. Managers associated with winter recreational developments should maintain high standards of food security to prevent wildlife species other than bears from becoming attracted to human facilities and foods. Garbage storage facilities should be secured from all forms of wildlife.

Planning for new winter recreational developments should include designs for animal-proof food- and garbage-storage facilities and avoid areas that could lead to animal attraction. Areas such as cooking and eating facilities, picnic areas, and garbage collection sites should be built to preclude wildlife attraction and habituation.

(2) Primary transportation routes and (3) scenic driving routes. Year-round roads may have significant effects on habituated wildlife. Primary roads may impact wildlife by creating situations where animals seek road habitats in search of food. This may occur because people feed wildlife along roadsides or, to a lesser extent, because animals scavenge dead animals killed along roads. Both types of foraging bring wildlife to roadsides and create further habituation and increase risk of mortality (Gunther et al. 1998). Wildlife managers should try to remove roadside carcasses to avoid scavengers being hit by vehicles.

(4) Groomed motorized routes. Snowmobile traffic along high- and moderate-groomed routes may pose a significant problem to habituated wildlife during the winter months. The potential for conflict could occur when animals seek groomed routes in search of food. This may occur from recreationists feeding wildlife along groomed roads or possibly with animals scavenging carcasses killed along these routes. Both types of feeding bring wildlife to groomed roadsides and create further habituation and increased risk of mortality. Wildlife managers should try to remove carcasses to prevent scavengers from being hit by over-snow vehicles.

Grooming of roads and snowmobile trails may affect ungulate movements, population dynamics, and management actions (Meagher 1993). Planning for new snow routes should avoid ungulate winter range and important wildlife habitat.

(6) Backcountry motorized areas. Ungroomed snowmobile areas may one day pose a significant habituated wildlife problem. Areas of ungroomed snowmobile use typically occur at low levels and should not attract wildlife. The potential for conflicts between wildlife and recreationists would occur when winter snowmobiling increases to higher densities and careless food security is common.

(9) Backcountry nonmotorized areas. Backcountry skiing, snowshoeing, and downhill sliding should not pose a problem to habituated wildlife. The potential for wildlife–human conflicts may occur when high-density, human winter recreational activity occurs and food security is a problem.

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EFFECTS OF HELISKIING ON WILDLIFE

Heliskiing is the use of helicopters to take skiers and snowboarders to the tops of mountain slopes that have generally been unused by other skiers or snowboarders. Typically, this activity occurs in the more remote backcountry mountains that are difficult to access by foot. Heliskiing is becoming popular in Colorado, Utah, Idaho, and Canada. Where there is snow and remote mountain slopes, there is the potential for heliskiing.

There is currently no permitted helicopter skiing use in the Greater Yellowstone Area (GYA), although a few requests have been made for permits on some forests. Some poaching (non-permitted use) does occur in the Bridger Range and may occur elsewhere.

Although helicopter skiing is not a current problem, managers need to look ahead and gather information on helicopter skiing to prevent conflicts between wildlife and heliskiers. Some managers on national forests where heliskiing now occurs state that if heliskiing is not now a permitted use in the GYA, then it should not be allowed.

Although some Potential Opportunity Areas in the GYA will not be directly accessed by skiers, the noise or sight of the helicopter will likely affect all the areas. Areas where the helicopter stages (*i.e.*, along roads, trailheads) could become a problem, and helicopters flying over wildlife winter range may affect the wintering wildlife. The Potential Opportunity Areas that will be most affected include:

(2) Primary transportation routes
(3) Scenic driving routes
(6) Backcountry motorized areas
(7) Groomed nonmotorized routes
(8) Nonmotorized routes
(9) Backcountry nonmotorized areas
(10) Downhill sliding (nonmotorized)
(11) Areas of no winter recreational use
(12) Low-snow recreation areas

POTENTIAL PROBLEMS WITH HELICOPTER SKIING

Numerous studies have shown impacts to wildlife from low-flying aircraft, including helicopters. Studies have been conducted on birds, mountain goats, wild sheep, deer, elk, and wolverines (Knight and Cole 1995). Exposure to helicopters increases energy expenditures, reduces fat accumulation, and/or changes an animal's physiological condition (MacArthur et al. 1979). These effects may lead to reduced survivability and/or reproduction success.

Other risks associated with helicopter skiing are avalanches, mishaps with the explosives used to set avalanches, and the potential for helicopter accidents. Helicopter accidents could result in wreckage and fuel spills in pristine backcountry areas. Any of these risks could be harmful to wildlife in the wrong place at the wrong time. Impacts from recreation add to the many stresses an animal sustains during the winter and can result in changes in movements and preferred ranges, reduced foraging efficiency, decreased reproductive success, increased chance of accidents, lowered resistance to disease, and increased predation (USFS 1996).

The impacts of helicopters on individual wildlife species are described below.

BALD EAGLES AND GOLDEN EAGLES

Bald eagles exhibited various responses to aircraft depending upon encounter distance and aircraft type. Eagles responded more negatively to helicopters within 1.8 miles than to fixed-winged aircraft. If young eagles were present, the adult eagles would remain on the nest, but if no young were present, the eagles would leave the nest and sometimes attack the helicopter. Researchers found no direct evidence of adult or young eagle mortality associated with aircraft harassment (Watson 1993). Watson suggests that the use of turbine-engine helicopters may have less impact on eagles, since these helicopters are quieter than piston-driven helicopters. All aircraft should remain a minimum of 65 yards from nests and stay within the nest area for less than 10 seconds. If there is a known nesting site, heliskiing operations should not be permitted within the area of the nest.

In the Wasatch Mountains of Utah, managers have expressed concern about a helicopter skiing permit that overlaps golden eagle range. It is likely that golden eagles would exhibit responses to helicopters similar to those of bald eagles.

MOUNTAIN GOATS

Mountain goats are found in all the mountain ranges of the GYA, and heliskiing areas could overlap with important winter habitats, potentially having a negative impact on the goats. Mountain goats winter at higher elevations, often at elevations higher than 7,000 feet, on south-facing slopes with windblown ridges. They prefer to be within 1,300 feet of escape terrain. In the winter months, goats minimize their movements, foraging during the warm parts of the day, decreasing energy expenditures.

A study of the effects of helicopter disturbance from mining activities showed some adverse impacts to mountain goats (Côté 1996). Côté found an inverse relationship between the goat's response to the altitude of the helicopter above the animal. He believes that mountain goats are more sensitive than other open-terrain ungulates. Goats responded most negatively when the helicopter was within 540 yards. Animals did not habituate to repeat overflights and responded in the same manner whether it was the first flight of the day or subsequent flights. When a helicopter was present in an area for many hours, the goats remained alert during the entire period and did not forage. Helicopters at close range caused mountain goat groups to split apart, and in some cases animals became injured. Côté recommends that a 1¼-mile buffer be placed around mountain goat herds to decrease the harmful effects of helicopters on the goats.

Similar negative impacts to goats were discussed in the environmental assessment of helicopter skiing on the Ketchum Ranger District of Idaho (USFS 1996). The biological assessment found that mountain goats ran when the helicopter was within 1/3 mile. Joslin (1986) noted that mountain goat behavior was changed negatively in response to helicopters used for seismic exploration. A study on the Beartooth Plateau, Montana, recommended that snowmobiles not be permitted within one mile of goat habitat (Haynes 1992); a similar recommendation should be made for helicopters.

If helicopter skiing is ever permitted in the GYA, mountain goat winter and spring ranges should be avoided.

ELK

Elk wintering at high elevations or along the route that a helicopter travels may be negatively affected by the aircraft because of increased energy expenditures in response to the disturbance. In the environmental assessment of helicopter skiing in the Ketchum Ranger District (USFS 1996), elk were identified as a species of concern.

BIGHORN SHEEP

Helicopter skiing would affect bighorn sheep in the same manner that it would affect mountain goats and elk. Jorgensen (1988) documented that bighorns abandoned winter range during the 1988 Winter Olympics. Helicopter flights, avalanche blasting, and human activity on ridge tops pushed the resident sheep to less optimal habitats. Bighorns are also negatively affected in the Grand Canyon as a result of helicopter overflights (Stockwell and Bateman 1991).

WOLVERINES

Female and male wolverines range 238.5 square miles and 983 square miles, respectively. Females den from mid-February through April. Den habitat is in subalpine, north-facing cirques with large boulder talus. This type of habitat is similar to the type of area used by heliskiers. Wolverines are sensitive during the denning periods, and females have been known to move their kits if people or human tracks are near the den site. Wolverines and helicopter skiing were discussed in the environmental assessment of helicopter skiing in the Ketchum Ranger District (USFS 1996). Heliskiing should be avoided in areas where wolverines are known to occur, especially if the activity is near denning habitat.

OTHER WILDLIFE

Many other species of wildlife could be negatively affected by helicopter skiing. Wolves and other carnivores may be impacted if prey species, such as elk, alter their behavior because of helicopter presence. There could be a positive result for predators if their prey becomes more susceptible to predation. Peregrine falcons may be bothered in the springtime during the breeding period if helicopter skiing is occurring in their territory. It is unknown how heliskiing might affect the lynx.

THE EFFECTS OF NOISE ON WILDLIFE

Knight and Cole (1995) examined the effects of noise on wildlife and found that noise from helicopters could be damaging to animals. Wildlife exposed to loud noises show an elevated heart rate. Noise can harm the health of an animal by altering reproduction (loss of fertility, harm during early pregnancy), survivorship, habitat use and distribution, abundance, or by interrupting torpor or hibernation. Animals may develop an aversion or avoidance response and show high levels of antagonistic behavior and decreased levels of food intake in areas with chronically loud noise. Animals may show signs of either acute or chronic hearing loss that could lead to masking other life-threatening noises, such as the approach of a predator. Wildlife abandonment of preferred habitat and the repeated reaction to avoid inescapable noises may lead to an increase in energetic expenses.

MANAGEMENT GUIDELINES

Heliskiing use should be limited to the minimal amount of area possible, and overflight distances should be more than 1,000 feet above and 2 miles away from sighted wildlife or known wildlife winter habitat. Managers should overfly proposed heliskiing areas to determine locations of wildlife and prohibit skiing where conflicts would occur. The permittee should be required to notify managers of any wildlife sightings as well as the areas that were used. Managers should have the authority to close any area that is in question. There should be no overflights or use of slopes with known wolverine dens. The use of explosives to set off avalanches should be limited, and any wildlife or human presence should be ascertained before use.

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HARASSMENT OF WILDLIFE BY THE PETS OF WINTER RECREATIONISTS

Harassment of wildlife by the pets of winter recreationists is increasing. Harassment is defined as any activity of humans and their associated domestic animals that increase the physiological costs of survival or decrease the probability of successful reproduction of wild animals. As winter recreational use increases and as people continue to take pets with them on their winter trips, the problem will continue to grow. The literature suggests that the primary problem is dogs chasing deer, but dogs can chase other wildlife, and cats can kill birds and small mammals.

Harassment of wildlife by pets is primarily occurring on national forest lands in the Greater Yellowstone Area (GYA) as pets are not allowed off-leash in the national parks. The extent of the problem in the GYA is unknown at this time.

POTENTIAL PROBLEMS WITH PET HARASSMENT OF WILDLIFE

Pets both chase and kill wildlife (George 1974, Lowry and McArthur 1978). In a 1958 study, mule deer in Missouri were chased from their home ranges by dogs, including one chase that lasted 3.25 miles (Progulske and Baskett 1958). This study also stated that dogs were a negligible cause of direct mortality of deer under the conditions of the study. Bowers (1953), however, found that free-running dogs killed more deer than legal hunters during a two-month winter period in Virginia.

In Yellowstone National Park in the summer of 1989, a domestic dog chased and caught a mule deer buck and tore off the deer's lower mandible. Park rangers subsequently destroyed the deer.

Being chased by a domesticated pet can disrupt a wild animal's energetic balance. Geist (1971) stated that running increases an ungulate's need for food and that these animals can become stressed to the point that they require more energy than they are able to take in. Consequently, the animals must use body reserves. Pregnant animals suffer higher stress levels, causing some animals to abort. A controlled study in Virginia (Gavitt 1973) used dogs to intentionally chase deer. The study found no significant differences in fawns per doe survival rates between deer that were chased and deer that were not chased. The study also found no changes in home range and that no healthy deer were caught by dogs.

Even if a direct chase does not occur, domestic pets can increase stress on wildlife. MacArthur et al. (1982) found that the greatest increase in bighorn sheep heart rates occurred when the sheep were approached by humans with a dog.

The literature suggests that deer are the primary target of harassment by pets and that dogs are the primary problem. But, cats have been implicated in killing a snowshoe hare (Doucet 1973) as well as birds and small mammals.

It is possible for domestic pets to transmit diseases to wildlife. Canine distemper, a severe and highly contagious virus, can be transmitted to both canids and mustelids. Transmission is primarily by aerosol or by direct contact with infected individuals. Mortality rates from canine distemper vary between species and range from 20–100 percent (Wyoming Game and Fish Department 1982). Yellowstone National Park has had one wolf and one pine marten mortalities from canine distemper (Douglas Smith, personal communication). Parvovirus is also a disease concern. In Isle Royale National Park, 25 wolves died in two years from a parvovirus epidemic that was most likely introduced from a domestic dog (Jack Oelfke, personal communication). Transmission is only a problem in dogs that have not been properly vaccinated.

MANAGEMENT RECOMMENDATIONS

Visitor education has the most promise for mitigating this potential problem. Informing people of the potential problem and asking them to leash pets in critical deer winter range could reduce chasing of wildlife. Direct restrictions on pets in critical deer winter range could be applied if educational efforts are not effective.

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EFFECTS OF SNOWMOBILING ACROSS OPEN WATER ON FISH AND WILDLIFE

Snowmobiling on open water involves a daring or, in some cases, intoxicated snowmobiler with a powerful machine who attempts to either make it across open water or to take a round trip on open water without submerging the snowmobile. If the snowmobile is submerged, the snowmobiler will hook onto it with a rope or chain and pull it out of the water using another snowmobile on the bank.

Snowmobiling on open water has the potential to affect water quality; aquatic species, such as invertebrates and trout; and riparian-dependent wildlife, specifically moose, furbearers, waterfowl (including trumpeter swans), and bald eagles.

This activity is currently not widespread in the Greater Yellowstone Area (GYA), but has occurred in a few isolated areas (the author has personal knowledge of the activity occurring on the Henrys Fork at Mack's Inn, Idaho, and D. Welch of the U.S. Forest Service has observed snowmobiles crossing open water on Island Park Reservoir). There is potential for this type of activity to increase because of its popularity in other parts of the country.

The most desirable waters for this activity are shallow ponds or shallow slow-moving streams with a gradually sloping bank where the machine can either exit or be retrieved if submerged. If the snowmobiler engages in this activity on a regular basis, it is desirable to choose locations near a facility where the wet snowmobiler can warm up and dry off.

Most waters in the GYA (lakes, ponds, and streams) are frozen throughout the winter period. However, some spring-fed streams, thermal waters, and areas where a stream empties into a lake or reservoir may remain open during part or all of the winter. Because the amount of open water is limited in the GYA during winter, it is critical to the survival of many wildlife species.

POTENTIAL EFFECTS

Snowmobiling on open water has the potential to pollute the water with snowmobile exhaust and spilled oil and/or gas, to stir up sediments on the bottom, to disturb winter-stressed fish and other aquatic wildlife, and to displace wildlife from important winter habitat. Bald eagles forage along open water, and waterfowl use open water for foraging and loafing during the winter. Moose use open water for foraging and travel and find security in the associated riparian vegetation. Several furbearers use open water and associated riparian vegetation during the winter.

A literature search produced little information on the effects of snowmobiling on open water. Adams (1975) found that lead and hydrocarbons from snowmobile exhaust were in the water at high levels during the week following ice-out in a Maine pond. Fingerling brook trout in the pond showed lead and hydrocarbon uptake. Stamina, as measured by the ability to swim against the current, was significantly less in trout exposed to snowmobile exhaust than in control fish. Gabrielsen and Smith (1995) found that fish stopped swimming in response to ground or sound vibration.

In the GYA, the Potential Opportunity Areas that will most likely be affected by snowmobiling on open water include:

(1) Destination areas
(2) Primary transportation routes
(12) Low-snow recreation areas

MANAGEMENT GUIDELINES

Agency managers need to be aware of the potential for snowmobile use on open water and that there are possible effects to water quality, fish, and wildlife. This activity is in defiance of common sense, and agencies should prohibit it on public land to avoid impacts to water quality, aquatic species, and riparian-dependent wildlife.

To maintain water quality, Bury (1978) suggests a shift to four-cycle engines in snowmobiles. Four-cycle engines produce less pollutants. Shea (1979) recommends that snowmobile trails be routed away from river courses to protect wintering swans.

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APPENDIX I: IMPACTS OF WINTER RECREATION ON WILDLIFE IN YELLOWSTONE NATIONAL PARK: A LITERATURE REVIEW AND RECOMMENDATIONS

by

James W. Caslick, Ph.D.

March 20, 1997

Report requested by the Branches of Planning and Compliance, Natural Resources, and Resources Management and Visitor Protection, Yellowstone National Park, Wyoming.

About the Author:

Dr. Caslick was a summer seasonal ranger in Yellowstone for three summers, starting in 1951. He was a wildlife biologist and directed a wildlife research laboratory for the U.S. Fish and Wildlife Service for 13 years. His graduate degrees are from Cornell University, where he taught wildlife research and management techniques for 18 years. Since retiring from Cornell, he and Mrs. Caslick have been full-time volunteers in Yellowstone for the past eight winters.

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Foreword

Numerous studies have concluded that wildlife is a major component of the Yellowstone experience, and a major economic "draw" to the area.

As increasing pressures for development of visitor facilities and new modes of transportation evolve, early consideration of their potential effects on wildlife (including individual animals, animal populations, and associated ecological processes) become ever more important, if wildlife resources are to continue to be a major feature of Yellowstone.

The purpose of this report is to briefly summarize and evaluate the published research on winter-recreation impacts on wildlife, particularly as they apply to Yellowstone, and to provide recommendations. This may have immediate application in decision-making during the trade-off processes that inevitably must occur when balancing resource conservation with visitor enjoyment.

Procedure

Starting in November 1996, I used "A Review of Potential Effects of Winter Recreation on Wildlife in Grand Teton and Yellowstone National Parks: A Bibliographic Data Base" by L. E. Bennett, 1995, as a starting point for the literature review. We obtained the electronic bibliographic component assembled with the ProCite bibliographic software program. I read the 139-page hard copy including the 465-entry bibliography, and deleted from our consideration 200 entries such as field guides that appeared to have little or no particular relevance to Yellowstone.

Using this shortened bibliography, I read as many of the relevant publications as could be located in Yellowstone and made reprint requests to authors and publishers. I also searched the new ProCite Natural History Database in the Yellowstone Research Library, and other bibliographies on the topic kindly provided by others. The Montana State University Library had previously been searched by K. Legg of the Office of Planning and Compliance, YNP, who advised that a repeat of that search probably would not be productive.

During my literature research, 211 new literature citations were discovered that seemed to have potential relevance to Yellowstone. Many of the most pertinent new literature sources that I found were in the M.S. and Ph.D. theses in the Yellowstone Research Library. All of these 211 new literature citations were listed in "New Citations on Winter Recreation Effects on Wildlife, J. and E. Caslick, 1997, 22 pp.," a copy of which is attached as Appendix 1. These new citations were then integrated with our revised list of Bennett (1995) to form "Selected Literature Citations from Bennett 1995 and New Citations from Caslick 1997 on Winter Recreation Effects on Wildlife, J. and E. Caslick, 1997, 74 pp.," a copy of which is attached as Appendix II. The new citations were also added to the revised ProCite database, now on file at YCR.

I met with the Visitor Use Management (VUM) Planning Team's Wildlife Resource Impacts Work Group on December 17/96, January 31, and February 24/97, sought their suggestions, and provided members with copies of 10 pertinent articles, as well as a draft of the new citations listing.

During the literature review and excerpting process, I attempted to retain the authors' interpretations by excerpting quotations; much can be lost otherwise. A summary of these findings in the literature was prepared as a matrix entitled "Matrix of Winter Recreation Effects on Wildlife, J. and E. Caslick, 1997, 25 pp.," a copy of which is attached as Appendix III. Rather than presenting a matrix chart with numbers that refer to a separate bibliography, it seemed much more immediately useful to excerpt the most pertinent information in the matrix and show the authors/ dates, thus allowing the user a choice of searching out the complete article, or using my excerpt without having to chase out the reference.

I found no documented impacts to mid-size carnivores. Although Yellowstone is believed to help support a viable population of wolverines, and lynx may have been resident over time, there is less evidence of historic or present fisher populations (Anon., National Park Service 1995:78). However, concern about the possibility of denning disturbance of wolverines by winter recreationists in high-altitude cirques was discussed by biologists at a VUM meeting in Bozeman this winter. Visitor impacts on coyotes have not been located in the literature, although in Yellowstone coyotes have long been observed to frequent plowed roads, snowmobile trails, ski trails, and other human trails, sometimes have been illegally fed, and apparently some coyotes have learned that they may be fed by humans. No research on this topic is listed in the 1995 YCR Investigators' Annual Report, although this continues to be a management concern. In an ongoing study of the effects of the l988 fires on coyotes, adult mortality was found to be "very low and primarily due to vehicles and mountain lions." Nine coyotes were reported killed by vehicles in the park in 1995 (Anon., National Park Service 1995). Although about 20 adult mountain lions inhabit Yellowstone's northern range, no impacts by recreationists other than by hunters outside the park have been documented (pers. comm. K. Murphy, Feb. 1997).

I have not included effects on vegetation or soils in this report, because most winter recreationists in Yellowstone use established trails or roadways, with snowcover present.

Time and the obscurity of some references precluded my review of all articles whose titles appeared to have some relevance to Yellowstone. I've included some of these in the matrix that may well be worthwhile to obtain and review.

In general, I feel fairly comfortable about the extent of my review of this topic. More could be done, of course, and review of new literature on the topic should be ongoing, particularly the emerging bodies of literature on wildlife energetics and nutrition in winter, stresses induced by human activities (including roads), the importance of habitat corridors, stressed ecosystems, and the developing science of ecotourism.

Summary of Literature Review

Much of the literature on this topic dates from the 1970s, when snowmobiles were new on the winter scene. There was a flurry of related papers, particularly from the Midwestern states, where several snowmobile conferences were held at universities. Many of the publications appeared in conference proceedings, not in refereed journals, so many literature citations are anecdotal accounts rather than reports of well-designed research projects that have tested hypotheses and used "controls." Reports sometimes conflicted with previous findings, but there was general agreement that winter recreation, particularly snowmobiling, had great potential for negatively impacting wildlife and wildlife habitats (particularly vegetation). Even in these early conferences, snowmobile manufacturers were urged by wildlife biologists, at least, to design machines that were quieter and less-polluting. Snowmobile-polluted snow and its effects on wildlife, fish, and other aquatic organisms have not been investigated in Yellowstone, although published accounts elsewhere began at least 24 years ago (see 8 literature citations on "Polluted Snow" in this report). This seems to be another topic that should have been researched here long ago, particularly since we probably experience a higher intensity of snowmobile use than anywhere else, and since our fish and wildlife resources are so highly concentrated and of such unique public value.

During the late 1970s and early 1980s, most of the publications on human impacts on wildlife dealt with impacts on nesting birds. Perhaps this is because such impacts are more readily evident and easier to quantify for birds than for mammals. Among birds, nesting shorebirds and waterfowl in refuges and parks were then the dominant topics. Later in the 1980s, literature began to be dominated by visitor effects on nesting bald eagles. Effects on ungulates began to be published as state game departments and the U.S. Forest Service became concerned. In 1985, Boyle and Samson published a benchmark bibliography of 536 references that identified 166 articles containing original data, and "reported that mechanized forms of recreation had the greatest impacts on wildlife, causing habitat disturbance, disrupting of animal behavior, noise pollution, and even direct mortality." (Purdy et al. 1987:6). The pace of publication slowed as some organizations imposed visitor-use restrictions, in a preventative mode, perhaps recognizing the difficulty and expense of definitive research. This is largely the situation today, although there is a slight increase of interest (largely academic) in quantifying nutritional and energetic stresses as they relate to ungulates and endangered species. The most recent publications of note deal with these latter topics, and with techniques for classifying, evaluating, and mitigating visitor use impacts.

By far, the most comprehensive single reference on this topic is a new book by several specialists in this field, "Wildlife and Recreationists: Coexistence Through Management and Research," by R.L. Knight and K.J. Gutzwiller, eds. (1995), Island Press, Washington, D.C., 372 pp. During this project, I contacted the publisher for copyright permission and provided copies of pertinent chapters to members of the VUM Planning Team's Wildlife Resource Impacts Work Group. Twenty chapters with different authors address such topics as Factors that Influence Wildlife Responses to Recreationists, Physiological Responses of Wildlife to Disturbance, Recreational

Disturbance and Wildlife Populations, and Indirect Effects of Recreationists on Wildlife. I highly recommend this book to anyone interested the current state of this topic.

The published concern about direct and indirect effects of winter recreationists on wildlife has not diminished among wildlife researchers elsewhere. From the early and obvious effects of intentional snowmobile harassment on wintering concentrations of wildlife, particularly in the Midwestern and eastern U.S., interest soon (although slowly) turned to unintended effects of winter recreation on wildlife. As early as 1975, Severinghaus and Tullar of the New York State Conservation Department were using energy expenditure calculations to demonstrate that deer already pressed by winter conditions should not be further stressed by snowmobiles, and recommended that snowmobile trails should be at least 1/2 mile from winter concentrations of white-tailed deer. Winter harassment of deer by snowmobiles was reported as detrimental to their winter adaptations for energy conservation in New York and Minnesota (Moen 1976, 1978), and winter energetics considerations and calculations for ungulates have continued as highly important research topics reported in peer-reviewed journals and are continuing today. Some of this energetics research has very recently been conducted by others in Yellowstone (see DelGuidice et al. 1994, 1991, for bison and elk), and could be tied to research on the energy expenditures required for locomotion by ungulates (see Parker et al. 1984, for mule deer and elk), to result in meaningful implications for recreation impacts on wintering wildlife in Yellowstone. In fact, Parker et al. (1984) discussed management implications based on energy-costs of locomotion for mule deer and elk, when disturbed by winter recreationists, and they pointed out that “the additional energy drain on a wintering population on poor range may be an important factor in survival” (p. 486). I consider winter-energetics research to be the most meaningful direction for “pure” research to further clarify the extent to which winter recreationists are negatively affecting winter-stressed wildlife in Yellowstone. (See Recommendations for Research #2, below).

Documented Impacts

In Yellowstone

As early as 1981, effects of winter recreationists on the physical environment of Yellowstone were reported to include air and snow pollution by snowmobile exhaust, litter, noise pollution, and limited damage to soils and plants in portions of the Madison, Firehole, and Gibbon river valleys (Aune 1981).

My review of the literature leaves me with no doubt that winter recreation activities in Yellowstone have affected wildlife behavior and survival, including bison use of groomed snowmobile trails (Aune 1981), and groomed-trail effects on changes in bison movements, habitat use, distribution and calf survival (Meagher 1993); Yellowstone elk have been affected by cross-country skiers (Aune 1981; Cassirer et al. 1992), and in Yellowstone, snowmobiling or cross-country skiers have caused most trumpeter swans to fly (Shea 1979).

Elsewhere in Montana and Wyoming

Elsewhere in Montana and Wyoming, published literature documents that snowmobile use has impacted deer, elk and small mammals (Aasheim 1980), bald eagles (Shea 1975; Alt 1980; Harmata 1996), an avian scavenger guild including bald eagles and black-billed magpies (Skagen et al. 1991), elk (Aasheim 1980) and bighorn sheep (Berwick 1968). There is no apparent reason to expect that similar effects would not occur in Yellowstone, where winter conditions are generally more severe and the intensity of snowmobile usage is generally higher than elsewhere in Montana and Wyoming.

Recommendations for Management

Winter Weather Considerations

Winters in Yellowstone are generally more severe than in any of the areas where recreational impacts on wildlife have been studied. This imposes an immediate constraint on applying the results of research conducted elsewhere; Yellowstone winters likely impose greater stresses on wildlife, even before visitor-induced stresses are added. For example, snowmobile activity in the Midwestern states has been shown to result in white-tailed deer movements away from trails. The energy cost of such movement at Midwestern snowdepths and temperatures are likely to be much less than for a similar movement under Yellowstone winter conditions. This movement must also be considered in the contexts of energy replacement costs and the quality of the habitat to which deer must move—must they now move more than previously to meet their energy requirements?

Proximity to and Overlap of Road Systems, Critical Winter Habitats (thermally-influenced) and Recreation Activities (road, trails, developments).

In Yellowstone, as elsewhere, there is a general shift of wildlife to lower-elevation habitats during winter. These habitats often are the riparian habitats in which the road system has been constructed. Since snowmobiling in Yellowstone is presently restricted to these established roadways, there is an immediate conflict in land uses. We have built our roads and developed areas in important (and perhaps key) wildlife wintering habitats, thereby reducing wildlife carrying capacity of the park. Winter uses and groomed roads are new environmental factors in these traditional wintering grounds, and we have yet to learn if and how some wildlife species, guilds, or populations will be affected in the long term. Some immediate effects are apparent, including displacement of individual animals and small groups, and associated energy expenditures by wildlife that result from recreationist activities and the related support and maintenance activities of the park and park concessioners.

There can be little doubt that continued human activity and additional commercial developments in these riparian areas will continue to degrade and diminish winter wildlife habitats, through depletion of resources previously available to wintering wildlife. This has been the pattern of wildlife population declines world-wide; there is no rationale for expecting results to be different here. Yellowstone now has wildlife in relative abundance because of a relatively low rate of human exploitation of habitats, but the clock is ticking and the exploitation rate is rapidly increasing.

The challenge for park managers is to apply the brakes now to slow the exploitation rate. Enforcement of park regulations alone will likely not suffice. Managers must make aggressive use of new techniques that promise to assist resource conservation efforts while concurrently accommodating visitor use. The science of ecotourism shows promise in this regard and park managers should explore its literature, learn how its principles are being applied in park management elsewhere (Anderson 1993; Blangley & Wood 1993; deGroot 1983; Wallace 1993), and stay tuned for further developments. The management emphasis here must be on conservation, education, then visitor use, in that order of priority, if the wildlife values of this park are to be retained in the long-term.

1. Reduce Snowmobiling Impacts in Thermally-Influenced Habitats

In regard to wildlife in Yellowstone, I conclude from my literature review that the most pressing VUM issue is snowmobiling—not snowmobiling in general, but snowmobiling in and near thermally-affected wildlife habitats that are known to be unique and of critical value to wildlife in winter. This value to Yellowstone wildlife is not conjecture; it has been widely recognized and published about for many years, particularly in regard to elk (USDI/NPS 1990), bison (Meagher 1970), bald eagles (Alt 1980; Swenson 1986, USDI/NPS 1990, 1995), and trumpeter swans (Shea 1979; USDI/NPS 1990). The Matrix of Winter Recreation Effects on Wildlife and Selected Literature Citations. . . attached as Appendices III and II support this view. From my literature review, I conclude that there is now ample documentation to administratively close these thermally-influenced winter habitats, prohibiting winter use by private and commercial snowmachines, skiers, snowshoers, and hikers.

To increase protection of these thermally-influenced wildlife habitats in winter and to interrupt the existing network of groomed trails now known to be used by Yellowstone elk and moose (USDI/NPS 1990) and bison (Aune 1981; Meagher 1993), I therefore recommend that private and commercial snowmachine use be permitted in the park only as follows:

(1) Mammoth to Indian Creek Campground
(2) West Entrance to 7-mile Bridge
(3) South Entrance to Lewis Lake Campground
(4) East Entrance to Sylvan Lake (or Sylvan Pass).

To further reduce impacts on wildlife, over-snow administrative travel on other park roads should be restricted to the middle hours of daylight (*i.e.*, 10 a.m. to 4 p.m.) to avoid wildlife disturbance during their early morning and evening feeding periods.

During winter, processes that influence energy intake, rather than energy expenditure, have a much greater influence on the energy balances of ungulates (Hobbs 1989).

2. Discontinue the "Harmful vs. Beneficial" Dichotomy.

I recommend that VUM planners and managers in Yellowstone discontinue speculation about whether particular impacts are harmful or beneficial to wildlife. Where management's objective is to maintain natural processes and minimize the effects of humans, such value judgments are inappropriate and unproductive. Rather, the appropriate challenges seem to be detection of impacts, quantification thereof, timely decisions on priorities for mitigation activities, and implementation of those activities.

3. Initiate Visitor Use Management Trials and Monitor the Results.

From years of experience in wildlife research and management, I am aware of the tendency to call for more research and thereby postpone important decisions until research results are available. Certainly more research on the topic of this report would be useful, and recommendations for research are given in a later section of this report. But there is a recent development in methodology for tackling complex management issues that does not seem to be in use in Yellowstone. This is the approach called for by Dr. N. Christensen when he delivered the Leopold Lecture at Yellowstone's First Biennial Scientific Conference in 1991. He said, "ignorance will not provide a reprieve from managing" and that through viewing management plans as "working hypotheses that can be tested over time," the challenges can be overcome (Anon. 1992) (emphasis added). This idea had been previously suggested by MacNab (1983) and most recently by Knight and Gutzwiller (1995), who suggested that serial management experiments can be used to assess cause and effect relationships - such as visitor use impacts - using temporal and spatial controls, randomized designs, covariates, and adequate replication. Note that these are management experiments not intended to replace long-term research, but to initiate action programs that may be helpful, while awaiting research results.

In Yellowstone, we don't need to prove that specific human activities are impacting wildlife before we initiate management measures. Where there are indications that impacts may be occurring, managers could undertake experimental management measures to reduce/minimize/eliminate these effects, while carefully documenting the results of the experimental management program. This documentation would provide a basis for making decisions about visitor use management needs and possibly elucidate priorities for research.

4. Adopt Standardized Terminology for Classification of Impacts and Impact-Mitigation Techniques.

Visitor use management in Yellowstone should be based on the recognition that there is no such thing as the non-consumptive use of wildlife or other natural resources. Every use exacts a toll. This has been a published view for at least 20 years (Wilkes 1977; Weedin 1981).

VUM then becomes a series of decisions about:

(1) what is the toll?
(2) is the toll acceptable?
(3) if not, how can the toll be reduced?

To classify impacts on wildlife, I recommend the scheme developed by Purdy et al. (1987) for the National Wildlife Refuges; these impacts are:

Direct Mortality
Indirect Mortality
Lowered Productivity
Reduced Use of Refuge (Park for YNP)
Reduced Use of Preferred Habitat
Aberrant Behavior/Stress

The classifications could as well serve as standards for evaluating visitor impacts on wildlife, and as standards evaluating the effectiveness of VUM measures in Yellowstone. The suggested measures of controlling visitor-related impacts on refuges (Visitor Education, Zoning, Restrictions on Activities, Law Enforcement, and various combinations of these measures) are all applicable here and could as well serve as a classification scheme for YNP mitigation efforts.

5. Consider Non-Visitor Impacts

The VUM plan should address impacts to wildlife that result from tour groups, scientists, educational activities (NPS, Yellowstone Institute, school groups, concessioner activities and NPS administrative activities) (see White and Bratton 1980). Mitigation techniques - initially evaluated as management trials - might include both temporal and spatial components. For example, during the period between official close of the park for the winter season and opening for the summer season, the park could restrict administrative travel on the previously groomed snowmobile routes to that required for official emergency travel only. Whenever possible, restrict even this emergency use to the mid-daylight hours (*i.e.*, 10 a.m. to 4 p.m.) to avoid disruption of the major feeding times for wildlife, during these critical weeks in wildlife survival.

6. Consider Sacrifice Areas

In defining VUM Potential Opportunity Areas, there seems to be an underlying assumption that it is desirable to distribute recreation throughout the greater Yellowstone area (p. 1, para. 3, Feb. 1996 draft). I recommend that this basic assumption be reconsidered to include the possibility that small sacrifice areas and large administrative closures may be ecologically preferable. For example, in Yellowstone, it may be preferable to dedicate a small area of low-quality wildlife habitat to heavy-use snowmobiling if, in so doing, a large thermal area of high-quality wildlife habitat is thereby protected.

7. Convene a Panel of Outside Specialists

Convene a panel of outside specialists on winter recreation effects on wildlife, specialists on human dimensions in wildlife management, and specialists in conflict resolution in resource management, to address the topic "Management of Winter Recreation Impacts on Wildlife in Yellowstone." Provide participants with copies of this report and other pertinent information, including NPS policy, prior to the meeting. Charge them with making recommendations for both immediate and long-term visitor management, and related short-term and long-term research projects and priorities. I can provide names of some potential participants. I recognize that suggestion of a panel of outside experts may strike fear in the hearts of some administrators, but recommendations may be accepted or rejected, and traditional public hearings in gateway communities cannot be expected to provide expertise or consensus. In fact, Dr. Kellert of Yale University, a specialist in public attitudes and the human dimensions of resource management, has published his view that public hearings are confrontational procedures that tend to harden positions and foster polarization. Like lake trout control, visitor use management here is a complex issue requiring input from specialists.

8. Prepare an EIS

Based upon the published effects of winter recreation on wildlife in Yellowstone that are documented here, and possibly including other air and water quality concerns in Yellowstone, promptly initiate preparation of an Environmental Impact Statement (EIS) on Winter Visitor Use in Yellowstone. In the EIS, include alternatives of "no snowmobiling" as well as alternatives for additional spatial and temporal restrictions on over-snow travel, as outlined above. Include consideration of alternative modes of transport for winter visitor enjoyment of park resources. Suspend further improvement and development of facilities to accommodate winter visitors (including Old Faithful Snowlodge), pending outcome of the NEPA process.

Recommendations for Research

The World Heritage Committee, an international panel of conservationists from countries that signed the World Heritage Convention in 1973, met in Yellowstone in 1995 and voted to add Yellowstone to a list of "endangered" sites that are "of universal value to mankind." The growing number of park visitors was one of the factors upon which this decision was based (Anon. 1996: 10).

Although Yellowstone has a Winter Use Resource Team, as of 1995 the team apparently had not decided whether increasing winter use was harmful to wildlife: "Increasing winter use may be harmful for wildlife . . ." (Anon. 1996:18) (emphasis added). Information gathered by the team in 1995 included a winter recreation and wildlife literature search by the University of Wyoming for Grand Teton National Park (Bennett 1995).

Winter visitor impacts were not a major area of emphasis reported in the Natural Resources Programs section of the Yellowstone Center for Resources 1995 Annual Report (Anon. 1996a). Although the 1990 Winter Use Plan Environmental Assessment for Yellowstone NP/Grand Teton NP/Rockefeller Parkway identified the need for more research on wildlife to determine "if visitor is causing impacts to wildlife" (USDI 1990:40) (emphasis added), Yellowstone's 1995 Investigators' Annual Report shows that no such studies have been initiated or currently are underway; the only projects listed as "visitor impacts" studies are a study of backcountry campsite use on conifer forest structure (Montana State University) and a study of human collection of artifacts scattered in a campground (University of Nebraska) (Anon. 1996b). There are no studies of visitor impacts on wildlife.

1. Actively Seek Outside Funding

It seems incredulous that so little research or management attention has been given or is now being given to this topic in this park. I therefore recommend that Yellowstone become pro-active in seeking outside funding from NSF and private sources such as the Rockefeller Foundation to support a well-planned research program that is coordinated with management efforts, and aimed at further clarifying visitor use/wildlife welfare relationships in this park. Invite park critics and others interested in this topic to financially support this new effort through the usual legislative processes and through direct contributions earmarked for this purpose.

2. Invite Research Proposals on Specific Topics

Invite research proposals from universities and others and prioritize funding to support those projects that address the most immediate needs of park management. Give highest priority to short-term projects that evaluate visitor use management strategies and to long-term projects that emphasize winter nutrition and energy budgets of wildlife, stress effects, survival strategies, and the modeling of these factors for population viability analyses. Focus on critical periods, critical habitats, synergistic effects and cumulative effects for wildlife present in Yellowstone, in winter.

Related studies such as that of Henry (1980), who examined relationships between visitor use and capacity for Kenya's Amboseli National Park, as a Ph.D. thesis, should also be encouraged and supported.

Thank you for the opportunity to review and summarize this literature, prepare this report, and make recommendations that I hope will be useful. I have appreciated the interest and support of the Yellowstone staff during completion of this project.

Attachments: 3

Appendix I

NEW CITATIONS ON WINTER RECREATION EFFECTS ON WILDLIFE

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Resource Management, YCR

Yellowstone Park, WY 82190

March 1997

These are literature citations that were not included in Bennett, L.E. 1995. A review of potential effects of winter recreation on wildlife in Grand Teton and Yellowstone National Parks: a bibliographic data base. Univ. of Wyo. Coop. Fish & Wildlife Research Unit, Laramie. 108 pp.

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   Note: new.
2. Anderson, D. L. A WINDOW TO THE NATURAL WORLD: THE DESIGN OF ECOTOURISM FACILITIES. In Ecotourism: A Guide for Planners and Managers, eds. K. Lindberg and D. E. Hawkins, 116-153. North Bennington, Vermont: The Ecotourism Society. 1993.
   Note: new.
   Emphasis on design to reduce environmental impacts and enhance visitors' satisfaction and awareness of the environment.
3. Anderson, S. H. RECREATIONAL DISTURBANCE AND WILDLIFE POPULATIONS. In R. L. Knight and K. J. Gutzwiller, eds. Wildlife and Recreation: Coexistence Through Management and Research. Island Press. Washington, D.C. 1995.
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4. Anthony, A. and E. Ackerman. EFFECTS OF NOISE ON THE BLOOD EOSINOPHIL LEVELS AND ADRENALS OF MICE. Journal of the Acoustical Society of America 27(6):1144-1149. 1955.
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5. Anthony, R. G., R. J. Steidl, and K. McGarigal. RECREATION AND BALD EAGLES IN THE PACIFIC NORTHWEST. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 223-241. Island Press. Washington, D.C. 1995.
   Note: new.
   Human disturbance is most serious for eagles that depend on large fish or mammal carcasses as their major food source.
6. Baldwin, F. M. THE OFF-ROAD VEHICLE AND ENVIRONMENTAL QUALITY; A REPORT ON THE SOCIAL AND ENVIRONMENTAL EFFECTS OF OFF-ROAD VEHICLES, PARTICULARLY SNOWMOBILES, WITH SUGGESTED POLICIES FOR THEIR CONTROL. The Conservation Foundation, Washington, D.C. 52 pp. 1970.
   Note: new.
   Clearly the effective way to protect fish and wildlife is not by restricting hunting or harassment alone, but by banning these vehicles from important habitats (p.25).
7. Baldwin, M. F. and D. H. Stoddard, Jr. THE OFF-ROAD VEHICLE AND ENVIRONMENTAL QUALITY: AN UPDATED REPORT ON THE SOCIAL AND ENVIRONMENTAL EFFECTS OF OFF-ROAD VEHICLES, PARTICULARLY SNOWMOBILES, WITH SUGGESTED POLICIES FOR THEIR CONTROL. 2nd ed. Conservation Foundation. Washington, D.C. 61 pp. 1973.
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9. Beier, P. DETERMINING MINIMUM HABITAT AREAS AND HABITAT CORRIDORS FOR COUGARS. Conser. Biol. 7:94-108. 1993.
   Note: new.

10. Bennett, L. E. A REVIEW OF POTENTIAL EFFECTS OF WINTER RECREATION ON WILDLIFE IN GRAND TETON AND YELLOWSTONE NATIONAL PARKS: A BIBLIOGRAPHIC DATABASE. Final Report. Mimeo. Sponsored by U.S. National Park Service in cooperation with Univ. of Wyoming Cooperative Fish and Wildlife Research Unit, Laramie. 141 pp. 1973.
    Note: new.
11. Berry, K. H. A REVIEW OF THE EFFECTS OF OFF-ROAD VEHICLES ON BIRDS AND OTHER VERTEBRATES. In: Management of Western Forests and Grasslands for Nongame Birds. Workshop Proceedings. U.S. For. Srv., Gen. Tech. Rep. INT-86, pp. 451-467. 1980.
    Note: new.
12. Bess, F. H. THE EFFECT OF SNOWMOBILE NOISE ON THE HEARING MECHANISM. Proceedings of the 1971 Snowmobile and Off-Road Vehicle Research Symposium. Sponsored by the Dept. of Park and Recreation Resources, Michigan State University, East Lansing, Michigan. 1971.
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    This three-volume compilation, with bibliography, reviews various studies conducted on the effects of aircraft noise on wildlife. A summary draws conclusions. Includes general disturbance factors.

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A literature review of 536 references which showed negative effects for most types of recreational activity. Suggests four management alternatives including "sacrifice" areas.

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167. Stankey, G. H., D. N. Cole, R. C. Lucas, M. E. Peterson, and S. S. Frissell. LIMITS OF ACCEPTABLE CHANGE (LAC) SYSTEM FOR WILDERNESS PLANNING. General Technical Report INT-176. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah. 19815.
Note: new.
Follows carrying capacity concepts (no set number of visitors). Sets quantifiable standards of impact levels that trigger management actions.

168. Stemp, R. E. HEART RATE RESPONSES OF BIGHORN SHEEP TO ENVIRONMENTAL FACTORS AND HARASSMENT. M. S. Thesis, Univ. of Calgary, Alberta, Canada. 371 pp. 1983.
Note: new.

169. Stockwell, C. A., G. C. Bateman, and J. Berger. CONFLICTS IN NATIONAL PARKS: A CASE STUDY OF HELICOPTERS AND BIGHORN SHEEP TIME BUDGETS AT GRAND CANYON. Biological Conservation 56:317-328.
Note: new.
Frequent alerting affected food intake.

170. Sweeney, J. M. and J. R. Sweeney. SNOW DEPTHS INFLUENCING WINTER MOVEMENTS OF ELK. Jour. of Mammalogy 65(3):524-526. 1984.
Note: new.

171. Taylor, C. R., N. C. Heglund, and G. M. Maloiy. ENERGETICS AND MECHANICS OF TERRESTRIAL LOCOMOTION. Jour. Exp. Biol. 97:1-21. 1982.
Note: new.

172. Telfer, E. S. and J. P. Kelsall. STUDIES OF MORPHOLOGICAL PARAMETERS AFFECTING UNGULATE LOCOMOTION IN SNOW. Can. Jour. Zool. 57:2153-2159. 1982.
Note: new.

173. Tennessee State University, Memphis. EFFECTS OF NOISE ON WILDLIFE AND OTHER ANIMALS. U.S. Govt. Printing Ofc., Washington, D.C. 74 pp. 1971.
Note: new.
Prepared for U.S. Ofc. of Noise Abatement and Control.

174. Tenpas, G. H. EFFECTS OF SNOWMOBILE TRAFFIC ON NON-FOREST VEGETATION. Lake Superior Biological Conference, Ashland, Wisc. 1972.
Note: new.

175. Thomas, J. W., ed. WILDLIFE HABITATS IN MANAGED FORESTS IN THE BLUE MOUNTAINS OF OREGON AND WASHINGTON. USDA Forest Service Handbook 553. 512 pp. 1979.
Note: new.
A most comprehensive study of deer and elk management. Provides tools for identifying cover and vegetation types. Quantifies impacts from management activities, including roads.

176. Thorne, E. T., R. E. Dean, and W. G. Hepworth. NUTRITION DURING GESTATION IN RELATION TO SUCCESSFUL REPRODUCTION IN ELK. J. Wildl. Manage. 40:330-335. 1976.
Note: new.

177. University of Wisconsin, Madison. EFFECTS OF SNOWMOBILE TRAFFIC ON NON-FOREST VEGETATION: SECOND REPORT. College of Agricultural and Life Sciences, Dept. of Agronomy, Univ. of Wisconsin, Madison. 1973.
Note: new.

178. USDI, U.S. National Park Service. PUBLIC USE AND RECREATION; VEHICLES AND TRAFFIC SAFETY. Federal Register 38. Feb. 14, 1973:4405-4407. 1973.
Note: new.

179. USDI, U.S. National Park Service. WINTER USE PLAN ENVIRONMENTAL ASSESSMENT, YELLOWSTONE AND GRAND TETON NATIONAL PARKS AND JOHN D. ROCKEFELLER, JR., MEMORIAL PARKWAY, WYOMING, IDAHO, AND MONTANA. 114 pp. 1990.
Note: new.

180. VanDyke, F. G., R. H. Brocke, H. G. Shaw, B. B. Ackerman, T. P. Hemker, and F. G. Lindzey. REACTIONS OF MOUNTAIN LIONS TO LOGGING AND HUMAN ACTIVITY. J. Wildl. Manage. 50:95-102. 1986.
Note: new.

181. Vaske, J. J., D. J. Decker, and M. J. Manfredo. HUMAN DIMENSIONS AND WILDLIFE MANAGEMENT: AN INTEGRATED FRAMEWORK FOR COEXISTENCE. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 33-49. Island Press. Washington, D.C. 1995.
Note: new.

182. Vaske, J. J., A. R. Graefe, and F. R. Kuss. RECREATION IMPACTS: A SYNTHESIS OF ECOLOGICAL AND SOCIAL RESEARCH. Trans. North Amer. Wildl. and Nat. Resour. Conf. 48:96-107. 1983.
Note: new.

183. Wallace, G. N. VISITOR MANAGEMENT: LESSONS FROM GALAPAGOS NATIONAL PARK. In: Ecotourism: A Guide for Planners and Managers, K. Lindberg and D. E. Hawkins, eds., pp.55-81. The Ecotourism Society. North Bennington, Vermont. 1993.
Note: new.

184. Walter, H. and K. L. Garrett. EFFECTS OF HUMAN ACTIVITY ON WINTERING BALD EAGLES IN THE BIG BEAR VALLEY, CALIFORNIA. FINAL REPORT. USDA Forest Service, Big Bear District, Fawnskin, Calif. 79 pp. 1981.
Note: new.
Snow machines and ATVs are especially disturbing, probably due to association with random movement, loud noise, and operators are generally exposed.

185. Wanek, W. J. and L. H. Schumacher. A CONTINUING STUDY OF THE ECOLOGICAL IMPACT OF SNOWMOBILING IN NORTHERN MINNESOTA. FINAL REPORT FOR 1974-1975. State College, Bemidji, Minn. 1975.
Note: new.

186. Wanek, W. J. ECOLOGICAL IMPACT ON VEGETATION AND SOIL MICROBES. In: Snowmobile and Off the Road Vehicle Research Symposium Proceedings. Recreation Resour., Michigan State Univ. 1973.
Note: new.

187. Wanek, W. J. SNOWMOBILING IMPACT ON VEGETATOIN, TEMPERATURES AND SOIL MICROBES. In: Snowmobile and Off the Road Vehicle Research Symposium Proceedings, pp. 117-130. 1971.
Note: new.

188. Ward, A. L. EFFECTS OF HIGHWAY CONSTRUCTION AND USE ON BIG GAME POPULATIONS. Fed. Highway Ofc. Res. and Dev. Rep. FHWA-RD-76-174. Nat. Tech. Inf. Serv., Springfield, Va. 92 pp. 1976.
Note: new.

189. Ward, A. L. TELEMETERED HEART RATE OF THREE ELK AS AFFECTED BY ACTIVITY AND HUMAN DISTURBANCES. In: Proceedings of Symposium: Dispersed Recreation and Natural Resource Management. Utah State Univ. 1977.
Note: new.
Two cow elk and a spike. Positive correlation to man-caused disturbance and elevated heart rates. Highest incidence occurred with loud noises and direct interaction.

190. Ward, A. L. and J. J. Cupal. TELEMETERED HEART RATE OF THREE ELK AS AFFECTED BY ACTIVITY AND HUMAN DISTURBANCE. Rocky Mt. Forest and Range Exper. Sta., Laramie, Wyo. 1980.
Note: new.

191. Warren, H. V. and R. E. Delavault, cited in H. L. Cannon and J. M. Bowles. CONTAMINATION OF VEGETATION BY TETRAETHYL LEAD. Science 137:765-766.
Note: new.

192. Watson, A. BIRD AND MAMMAL NUMBERS IN RELATION TO HUMAN IMPACT AT SKI LIFTS ON SCOTTISH HILLS. Jour. of Applied Ecology 16:753-754. 1979.
Note: new.

193. Whelan, T. ed. NATURE TOURISM: MANAGING FOR THE ENVIRONMENT. Island Press. Washington, D.C. 1991.
Note: new.

194. White, P. S. and S. P. Bratton. AFTER PRESERVATION; PHILOSOPHICAL AND PRACTICAL PROBLEMS OF CHANGE. Biol. Conservation 18:241-255. 1980.
Note: new.
It is not only the recreationist who impacts wildlands, but the scientist, educator, and school group as well.

195. Whittaker, J. SNOWMOBILING OVER FORAGE GRASSES. Paper presented at Conference on Snowmobiles and All-terrain Vehicles at Univ. of Western Ontario, Canada. 1971.
Note: new.

196. Wiens, J. A. SPATIAL SCALING IN ECOLOGY. Functional Ecology 3:385-397. 1989.
Note: new.

197. Wilcox, B. A. and D. D. Murphy. CONSERVATION STRATEGY: THE EFFECTS OF FRAGMENTATION ON EXTINCTION. Am. Nat. 125:879-887.
Note: new.

198. Williams, M. and A. Lester. ANNOTATED BIBLIOGRAPHY OF OHV AND OTHER RECREATIONAL IMPACTS TO WILDLIFE. Eldorado National Forest. USDA Forest Service, Pacific Southwest Region. 10 pp. 1996.
Note: new.

199. Witmer, G. W. and D. S. deCalesta. EFFECT OF FOREST ROADS ON HABITAT USED BY ROOSEVELT ELK. Northwest Science 59(2):122-124. 1985.
Note: new.
Six females monitored for one year. Human activity on forest roads alters distributions of elk habitat use. Impact may be mitigated by road closures, especially during rutting and calving seasons.

200. Young, J. and A. Boyce. RECREATIONAL USES OF SNOW AND ICE IN MICHIGAN AND SOME OF ITS EFFECTS ON WILDLIFE AND PEOPLE. In: Proceedings of the Snow and Ice Symposium. Iowa Coop. Wildl. Res. Unit, Iowa State Univ., Ames. 820 pp. 1971.
Note: new.
Includes skiing.

ADDENDUM

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——— 1996a. Yellowstone Center for Resources 1995 Annual Report, S. Consolo Murphy, M.A. Franke and S. Broadbent, eds., Yellowstone Park, Wyo. 82 pp.

——— 1996b. Investigators' Annual Reports for 1995, B. Lindstrom and S. Broadbent, eds., Yellowstone Park, Wyo. 134 pp.

Barnes, V.G. Jr. and O.E. Bray. 1967. Final report: Population characteristics and activities of black bears in Yellowstone National Park. Colo. Coop. Wildl. Research Unit, Colo. State Univ., Fort Collins. 199 pp.

Beall, R.C. 1974. Winter habitat selection and use by a western Montana elk herd. Ph.D. Thesis. Univ. of Montana, Missoula. 197 pp.

Cole, G.F. 1972. Grizzly bear-elk relationships in Yellowstone National Park. J. Wildl. Manage. 36(2):556-570.

DelGuidice, G., F.J. Singer, U.S. Seal and G. Bowser. 1994. Physiological responses of Yellowstone bison to winter nutritional deprivation. J. Wildl. Manage. 58(1):24-34.

Goodrich, J.M. and J. Berger. 1994. Winter recreation and hibernating black bears <u>Ursus americanus</u>. Biological Conservation 67:105-110.

Green, G.I. 1988. Dynamics of ungulate carcass availability and use by bears on the northern range and Firehole and Gibbon drainages. Yellowstone Grizzly Bear Investigations: Annual Report of the Interagency Bear Study Team, R.R. Knight, B.M. Blanchard and M. Mattson, eds., U.S. National Park Service, Bozeman, Mont.

Mattson, D. J. and J. Henry. 1987. Spring grizzly bear use of ungulate carcasses in the Firehole River drainage: Second Year Progress Report. Pp. 63-72 in Yellowstone Grizzly Bear Investigations: Annual Report of the Interagency Study Team 1986. USDI National Park Service. Bozeman, Mont.

Thurber, J.M., R.O. Peterson, T.D. Drummer, and S.A. Thomasa. 1994. Gray wolf response to refuge boundaries and roads in Alaska. Wildl. Soc. Bull. 22(1):61-68.

Wesley, D.E., K.L. Knox and J.G. Nagy. 1973. Energy metabolism of pronghorn antelope. J. Wildl. Manage. 57:563-573.

Appendix II

SELECTED LITERATURE CITATIONS FROM BENNETT 1995[1] AND NEW CITATIONS FROM CASLICK 1997[2] ON WINTER RECREATION EFFECTS ON WILDLIFE

J. and E. Caslick
Resource Management, YCR
Yellowstone Park, WY 82190

March 1997

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[1] Bennett, L.E. 1995. A review of potential effects of winter recreation on wildlife in Grand Teton and Yellowstone National Parks: a bibliographic data base. Univ. of Wyo. Coop. Fish and Wildlife Research Unit, Laramie. 108 pp.

[2] Caslick, J. and E. 1997. New citations on winter recreation effects on wildlife. Resource Management, YCR, Yellowstone Park, Wyo. 22 pp.

1. Aasheim, R. SNOWMOBILE IMPACTS ON THE NATURAL ENVIRONMENT. in: R. N. L. Andrews; and P. F. Nowak, eds. Off-road Vehicle use: A Management Challenge; Conf. Proc., 16-18 March 1980. Ann Arbor, MI. 1980.
   Snowmobiling and its impacts on natural environments in Montana are described. Studies of impacts on deer and elk have produced conflicting results, but there is little doubt that additional stress in winter is undesirable. Animals accustomed to humans are less affected by snowmobiles than animals in more remote areas. Effects on small mammals and possible effects of packed snowmobile trails are discussed.
2. Adams, E. S. EFFECTS OF LEAD AND HYDROCARBONS FROM SNOWMOBILE EXHAUST ON BROOK TROUT (*Salvalinus fontinalis*). Trans. Amer. Fish Soc.; 104(2):363-373. 1975.
   Field and lab study on fingerling brook trout.
3. Allbrecht, J.; and D. Smith. ENVIRONMENTAL EFFECTS OF OFF-ROAD VEHICLES: A SELECTED BIBLIOGRAPHY OF PUBLICATIONS IN THE UNIVERSITY OF MINNESOTA FORESTRY LIBRARY. Univ. Minnesota, St. Paul Campus Libraries, For. Serv. Libr. Bibligr. Ser. 2. 9 pp. 1977.
   *Bibliography.
4. Alldredge, R. B. SOME CAPACITY THEORY FOR PARKS AND RECREATION AREAS. National Park Service Reprint. 1972.
5. Allen, J. N. *THE ECOLOGY AND BEHAVIOR OF THE LONG-BILLED CURLEW IN SOUTHEASTERN WASHINGTON. Wildl. Monogr. 73:1-67. 1980.
6. Allen, R. P. *THE WHOOPING CRANE. National Audubon Society, Rep. 3, New York. 246 pp. 1952.
7. Allendorf, F. W.; and C. Serveen. *GENETICS AND THE CONSERVATION OF GRIZZLY BEARS. Trends in Ecol. and Evol.; 1:88-89. 1986.
8. Alt, K. L. ECOLOGY OF THE BREEDING BALD EAGLE AND OSPREY IN THE GRAND TETON-YELLOWSTONE NATIONAL PARKS COMPLEX. M. S. thesis. Univ. of Montana. 95 pp. 1980.
   Note: new.
9. Altman, M. THE FLIGHT DISTANCE IN FREE-RANGING BIG GAME. J. Wildl. Manage.; 22(2):207-209. 1958.
   The distance at which free-ranging elk and moose would flee from humans varied with habitat, social groupings, nutrition, reproductive status, and specific experience of individual animals of the group (Ream 1980).
10. Anderson, D. L. A WINDOW TO THE NATURAL WORLD: THE DESIGN OF ECOTOURISM FACILITIES. In Ecotourism: A Guide for Planners and Managers, eds. K. Lindberg and D. E. Hawkins, 116-153. North Bennington, Vermont: The Ecotourism Society. 1993.
    Note: new.
    Emphasis on design to reduce environmental impacts and enhance visitors’ satisfaction and awareness of the environment.

11. Anderson, D. W.; and J. O. Kieth. THE HUMAN INFLUENCE ON SEABIRD NESTING SUCCESS: CONSERVATION IMPLICATIONS. Biol. Conserv.; 18:65-80. 1980.
Studies of brown pelicans and Heerman's gulls indicated that disturbances by recreationists, educational groups, and scientists could seriously disrupt seabird breeding on the coast of Baja California. Human disturbances lead to inter- and intra-specific behavioral imbalances in seabirds. Methods for minimizing disturbances are discussed (Boyle and Sampson 1983).

12. Anderson, E. M. *A CRITICAL REVIEW AND ANNOTATED BIBLIOGRAPHY OF LITERATURE ON THE BOBCAT. Colorado Division of Wildlife, Special Report No. 62. 61 pp. 1987.

13. Anderson, S. H. *COMPARATIVE FOOD HABITS IN OREGON NUTHATCHES. Northwest Sci.; 50:213-221. 1976.

14. Anderson, S. H. RECREATIONAL DISTURBANCE AND WILDLIFE POPULATIONS. In R. L. Knight and K. J. Gutzwiller, eds. Wildlife and Recreation: Coexistence Through Management and Research. Island Press. Washington, D.C. 1995.
Note: new.

15. Anthony, A. and E. Ackerman. EFFECTS OF NOISE ON THE BLOOD EOSINOPHIL LEVELS AND ADRENALS OF MICE. Journal of the Acoustical Society of America 27(6):1144-1149. 1955.
Note: new.

16. Anthony, R. G., R. J. Steidl, and K. McGarigal. RECREATION AND BALD EAGLES IN THE PACIFIC NORTHWEST. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 223-241. Island Press, Washington, D.C. 1995.
Note: new.
Human disturbance is most serious for eagles that depend on large fish or mammal carcasses as their major food source.

17. Armstrong, F. H. *NOTES ON SOREX PREBLEI IN WASHINGTON STATE. Murrelet; 38:6. 1957.

18. Aune, K. E. IMPACT OF WINTER RECREATIONISTS ON WILDLIFE IN A PORTION OF YELLOWSTONE NATIONAL PARK, WYOMING. M.S. thesis; Montana State Univ., Bozeman. 111 pp. 1981.
General responses of wildlife to winter recreationists in Yellowstone National Park were attention or alarm, light, and, rarely, aggression. Responses varied with the species involved, nature of the disturbance, and time of season. Winter recreation activities was not a major factor influencing wildlife distributions, movements, or population sizes, although minor displacement of wildlife from areas adjacent to trails was observed. Management recommendations are presented (Boyle and Sampson 1983).

19. Austin, J. E. WINTER ECOLOGY OF CANADA GEESE IN NORTHCENTRAL MISSOURI. Ph.D., University of Missouri, Columbia. 284 pp. 1988.
    Canada geese tended to spend more of their time in agricultural habitats where they were more vulnerable to disturbances than in seasonal wetlands in the refuge interior or the water roost sites. Vigilance of waterfowl did not differ by habitat in the hunting season, thus the effects of disturbances by hunters are far-reaching. All use of wetlands in late fall occurred in the refuge interior, which is not hunted. However, in response to gunshots from the hunting zone, geese in the refuge interior often ceased other activities and, at least briefly, became alert or vigilant. Habituation of Canada geese to disturbances in some locations may account for the lower vigilance of geese in pastures in winter. These pastures seemed to be traditionally used by geese and may be considered safe fields. Geese seemed to avoid or leave locations where excessive disturbances restricted feeding and where they did not habituate to disturbances.
20. Bailey, T. N. *FACTORS OF BOBCAT SOCIAL ORGANIZATION AND SOME MANAGEMENT IMPLICATIONS. Pages 984-1000 in: J. A. Chapman and D. Pursley, eds. Proc. Worldwide Furbearer Conf., Frostburg, MD. 1981.
21. Baldwin M. F., and D. H. Stoddard. THE OFF-ROAD VEHICLE AND ENVIRONMENTAL QUALITY. Second edition, the Conservation Foundation; Washington, D.C. 61 pp. plus foldout chart. 1973.
    This report updates an earlier edition describing the effects of off-road vehicles, particularly snowmobiles. A section on fish and wildlife reviews literature describing harassment of wildlife, and legal responses to adverse impacts of off-road vehicles on wildlife. Policies for control of environmental impacts are suggested (Boyle and Sampson 1983).
22. Baldwin, F. M. THE OFF-ROAD VEHICLE AND ENVIRONMENTAL QUALITY; A REPORT ON THE SOCIAL AND ENVIRONMENTAL EFFECTS OF OFF-ROAD VEHICLES, PARTICULARLY SNOWMOBILES, WITH SUGGESTED POLICIES FOR THEIR CONTROL. The Conservation Foundation, Washington, D.C. 52 pp. 1970.
    Note: new.
    Clearly the effective way to protect fish and wildlife is not by restricting hunting or harassment alone, but by banning these vehicles from important habitats (p.25).
23. Baldwin, M. F. and D. H. Stoddard, Jr. THE OFF-ROAD VEHICLE AND ENVIRONMENTAL QUALITY: AN UPDATED REPORT ON THE SOCIAL AND ENVIRONMENTAL EFFECTS OF OFF-ROAD VEHICLES, PARTICULARLY SNOWMOBILES, WITH SUGGESTED POLICIES FOR THEIR CONTROL. 2nd ed. Conservation Foundation. Washington, D.C. 61 pp. 1973.
    Note: new.
24. Baldwin, M. F. THE SNOWMOBILE AND ENVIRONMENTAL QUALITY. Living Wilderness; 32(104):14-17. 1968.
    Recreational uses of snowmobiles is examined in terms of effects on environmental quality through noise, fumes, and impacts on fish, wildlife and trails. Harassment of wild game, nongame, and predators by snowmobile users is described. Policy recommendations are suggested and discussed (Boyle and Sampson 1983).

25. Banko, W. E. *THE TRUMPETER SWAN. N. Am. Fauna 63, U.S. Fish Wildl. Ser., Washington, D.C. 214 pp. 1960.

26. Basil, J. V.; and T. N. Lonner. VEHICLE RESTRICTIONS INFLUENCE ELK AND HUNTER DISTRIBUTION IN MONTANA. J. Forestry; 77:155-159. 1979.

27. Batcheler, C. L. COMPENSATORY RESPONSES OF ARTIFICIALLY CONTROLLED MAMMAL POPULATIONS. Proc. of the New Zealand Ecol. Soc.; 15:25-30. 1968.

28. Bayfield, N. G. SOME EFFECTS OF WALKING AND SKIING ON VEGETATION AT CAIRNGORM. J. Applied Ecology 7:469-485. 1970.
    Note: new.

29. Bear, G. D.; and G. W. Jones. HISTORY AND DISTRIBUTION OF BIGHORN SHEEP IN COLORADO. Colorado Division of Wildlife, Denver, CO. 232 pp. 1973.
    Available information on the history, distribution, population trends, and ecological factors for bighorn sheep herds in Colorado are summarized. Human influences are discussed for each of the herds; while few quantitative data are available, observations suggest that in many cases, such as camping, hiking, and driving off-road vehicles, influence sheep distributions and activities (Boyle and Sampson 1983).

30. Beier, P. DETERMINING MINIMUM HABITAT AREAS AND HABITAT CORRIDORS FOR COUGARS. Conserv. Biol. 7:94-108. 1993.
    Note: new.

31. Belanger, L.; and J. Berdard. ENERGETIC COST OF MAN-INDUCED DISTURBANCE TO STAGING SNOW GEESE. J. Wildl. Manage.; 54:36-41. 1990.

32. Bell, J. N. WILD ANIMALS ARE WILD. Natl. Wildl.; 1(5):34-36. 1963.
    Problems of human-wildlife interactions in National Parks are described in this popular article. Park visitors unaware of the potential hazards of confrontations with wildlife sometimes create dangerous situations by inappropriate behavior. Park visitors are entitled to wildlife viewing experiences, but must be educated about wildlife behavior and maintain respect for wild animals (Boyle and Sampson 1983).

33. Bennett, L. E. COLORADO GRAY WOLF RECOVERY: A BIOLOGICAL FEASIBILITY STUDY. Univ. Wyo. Coop. Fish Wildl. Res. Unit. Laramie. 318 pp. 1994.

34. Bennett, L. E. A REVIEW OF POTENTIAL EFFECTS OF WINTER RECREATION ON WILDLIFE IN GRAND TETON AND YELLOWSTONE NATIONAL PARKS: A BIBLIOGRAPHIC DATABASE. Final Report. Mimeo. Sponsored by U.S. National Park Service in cooperation with Univ. of Wyoming Cooperative Fish and Wildlife Research Unit, Laramie. 141 pp. 1995.
    Note: new.

35. Berry, K. H. A REVIEW OF THE EFFECTS OF OFF-ROAD VEHICLES ON BIRDS AND OTHER VERTEBRATES. In: Management of Western Forests and Grasslands for Nongame Birds. Workshop Proceedings. U.S. For. Srv., Gen. Tech. Rep. INT-86, pp. 451-467. 1980.
    Note: new.

36. Berwick, S. H. OBSERVATIONS ON THE DECLINE OF THE ROCK CREEK, MONTANA, POPULATION OF BIGHORN SHEEP. M.S. thesis; Univ. of Montana, Missoula. 245 pp. 1968.
Among factors that may be responsible for an observed decline in a Montana bighorn sheep population are human disturbance and harassment of sheep. Snowmobile use of an important segment of sheep winter range is increasing. It is suggested that harassment may be debilitating to winter-stressed animals (Boyle and Sampson 1983).

37. Bess, F. H. THE EFFECT OF SNOWMOBILE NOISE ON THE HEARING MECHANISM. Proceedings of the 1971 Snowmobile and Off-Road Vehicle Research Symposium. Sponsored by the Dept. of Park and Recreation Resources, Michigan State University, East Lansing. 1971.
Note: new.

38. Bird, D. M. BIRDS OF PREY: A PLEA FOR ETHICS. Ont. Nat.; 17(5):16-23. 1978.
Problems facing birds of prey are described in this nontechnical article. Effects of man on raptors are discussed, including impacts on research, wildlife photography, and bird watching. Disturbances of birds by these activities can cause adults to abandon nests, and decrease survival of eggs and young through predation or exposure. Education of public on the values of birds of prey is essential for their protection (Boyle and Sampson 1983).

39. Bissell, L. P. THE SOCIAL AND POLITICAL IMPACT OF SNOWMOBILES. In: Proceedings 3rd International Snowmobile Congress, Portland, Maine. pp.58-62. 1970.
Note: new.

40. Bjarvall, A. NORTH AMERICAN STUDIES ON THE EFFECTS OF SNOWMOBILES ON FAUNA. Flora Fauna. 1974.
Note: new.

41. Blackford, J. L. *WOODPECKER CONCENTRATION IN BURNED FOREST. Condor; 57:28-30. 1955.

42. Blangley, S. and M. E. Wood. DEVELOPING AND IMPLEMENTING ECOTOURISM GUIDELINES FOR WILDLANDS AND NEIGHBORING COMMUNITIES. In: Ecotourism: A Guide for Planners and Managers, K. Lindberg and D. E. Hawkins, eds., pp. 32-54. North Bennington, Vermont; The Ecoturism Society. 1993.
Note: new.

43. Blokpoel, H. AN ATTEMPT TO EVALAUTE THE IMPACT OF CANNON-NETTING IN CASPIAN TERN COLONIES. Colon. Waterbirds; 4:61-67. 1981.
From studies of Caspian terns on Lake Huron, Ontario, it was found that visits to tern colonies resulted in losses of eggs to predation by gulls. Human activities at tern nesting colonies should be restricted until more is known about the nature and extent of human-induced nest losses (Boyle and Sampson 1983).

44. Bock, C. E., and J. H. Bock. *ON THE GEOGRAPHICAL ECOLOGY AND EVOLUTION OF THE THREE-TOED WOODPECKERS. Am. Midl. Nat.; 92:397-405. 1974.

45. Bollinger, J. G., O. J. Rongstad, A. Soom, and R. G. Eckstein. SNOWMOBILE NOISE EFFECTS ON WILDLIFE. 1972-1973 report. Engineering Exp. Sta., Univ. of Wisconsin, Madison. 85pp. 1973.
Note: new.

46. Boucher, J., and T. A. Tattar. SNOWMOBILE IMPACT ON VEGETATION. Forest Notes 120:27-28. 1974.
Note: new.

47. Bowles, A. E. RESPONSES OF WILDLIFE TO NOISE. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 109-156. Island Press, Washington, D.C. 1995.
Note: new.

48. Bowles, A., B. Tabachnick, and S. Fidell, eds. REVIEW OF THE EFFECTS OF AIRCRAFT OVERFLIGHTS ON WILDLIFE. National Park Service, Report No. 7500. 373 pp. 1991.
Note: new.
This three-volume compilation, with bibliography, reviews various studies conducted on the effects of aircraft noise on wildlife. A summary draws conclusions. Includes general disturbance factors.

49. Boyce, M. S. POPULATION VIABILITY ANALYSIS. Annu. Rev. Ecol. Syst. 23:481-506. 1992.
Note: new.

50. Boyce, M. S.; and L. D. Hayden-Wing. *NORTH AMERICAN ELK: ECOLOGY, BEHAVIOR AND MANAGEMENT. Univ. Wyo., Laramie. 294 pp. 1971.

51. Boyd, R. J. *AMERICAN ELK. Pages 10-29 in: J. D. Schmidt and D. L. Gilbert, eds. Big game of North America. Stackpole Books, Harrisburg, PA., and Wildl. Manage. Inst., Washington, D.C. 1978.

52. Boyle, S. A. and F. B. Samson. EFFECTS OF NONCONSUMPTIVE RECREATION ON WILDLIFE: A REVIEW. Wildlife Society Bull. 13(2):110-116. 1985.
Note: new.
A literature review of 536 references which showed negative effects for most types of recreational activity. Suggests four management alternatives including “sacrifice” areas.

53. Boyle, S. A. and F. B. Samson. EFFECTS OF NONCONSUMPTIVE RECREATION ON WILDLIFE: A REVIEW. Wildl. Soc. Bull. 13:110-116. 1985.
Note: new.

54. Boyle, S. A.; and F. B. Samson. NONCONSUMPTIVE OUTDOOR RECREATION: AN ANNOTATED BIBLIOGRAPHY OF HUMAN -WILDLIFE INTERACTIONS. USDI, U.S. Fish Wildl. Serv. Special Sci. Rep. No. 252. 1983.
*Annotated Bibliography.

55. Brand, C. J.; L. B. Keith; and C. A. Fischer. *LYNX RESPONSES TO CHANGING SNOWSHOE HARE DENSITIES IN CENTRAL ALBERTA. J. Wildl. Manage.; 40:416-428. 1976.

56. Budowski, G. TOURISM AND ENVIRONMENTAL CONSERVATION: CONFLICT, COEXISTENCE, OR SYMBIOSIS? Environ. Conserv.; 3:27-31. 1976.
Relationships between tourism and conservation are described as conflicting, coexisting, or symbiotic. Widespread environmental degradation has often resulted from tourism, as many places visited by tourists support fragile ecosystems. Proper attitudes and management schemes can lead to symbiotic relationships instead of conflicts (Boyle ans Sampson 1983).

57. Buehler, D. A.; T. J. Mersmann; J. D. Fraser; and J. K. D. Seegar. EFFECTS OF HUMAN ACTIVITY ON BALD EAGLE DISTRIBUTION ON THE NORTHERN CHESAPEAKE BAY. J, Wildl. Manage.; 55:282-290. 1991.

58. Buehler, D. A.; T. J. Mersmann; J. D. Fraser; and J. D. Seegar. NONBREEDING BALD EAGLE COMMUNAL AND SOLITARY ROSSTING BEHAVIOR AND ROOST HABITAT ON THE NORTHERN CHESAPEAKE BAY. J. Wildl. Manage. 55(2):273-281. 1990.

    The authors studied roosting behavior and habitat use of nonbreeding bald eagles on the northern Chesapeake Bay during 1986-1989. Results of the study included the recommendation that a 1,360-m-wide shoreline management zone that extends 1,400 m inland should be provided to encompass roost sites and provide a buffer from human disturbance.

59. Buell, N. E. REFUGE RECREATION: HIGH STANDARDS EQUAL QUALITY. Living Wilderness; 31(98):24-26. 1967.

    The role of U.S. National Wildlife Refuges in providing recreational opportunities is discussed in this popular article. Planning for recreation on refuges is based on the view that quality of experience rather than quantity of use is most desirable to visitors and protected wildlife. Responsibilities and approaches to recreation management are discussed (Boyle and Samson 1983).

60. Bull, E. L. *ECOLOGY OF THE PILEATED WOODPECKER IN NORTHEASTERN OREGON. J. Wildl. Manage.; 51(2):472-481. 1987.

61. Bull, E. L.; and M. G. Henjum. *THE NEIGHBORLY GREAT GRAY OWL. Natural History; 9:32-41. 1987.

62. Burger, J. THE EFFECT OF HUMAN ACTIVITY ON SHOREBIRDS IN TWO COASTAL BAYS IN NORTHEASTERN UNITED STATES. Environ. Conserv.; 13:123. 1986.

63. Burger, J. FORAGING BEHAVIOR AND THE EFFECTS OF HUMAN DISTURBANCE ON THE PIPING PLOVER. J. Coast. Res.; 7:39-52. 1991.

64. Burk, D. ed. *THE BLACK BEAR IN MODERN NORTH AMERICA. Proc. of the workshop on the management biology of the North American black bear, Kalispell, MT., 17-19 Feb 1977. Boone and Crockett Club, New York, and Amwell Press, Clinton, N.J. 300 pp. 1979.

65. Burkey, T. V. EXTINCTION IN NATURE RESERVES: THE EFFECT OF FRAGMENTATION AND THE IMPORTANCE OF MIGRATION BETWEEN RESERVE FRAGMENTS. Oikos 55:75-81. 1989.

    Note: new.

66. Bury, R. EFFECTS OF OFF-ROAD VEHICLES ON DESERT VERTEBRATES. Bulletin of the Ecological Society of America 56(2):40. 1975.

    Note: new.

67. Bury, R. B., R. A. Luckenbach, and S. D. Busak. EFFECTS OF OFF-ROAD VEHICLES ON VERTEBRATES IN CALIFORNIA. USDI Fish & Wildlife Service. 1977.
Note: new.
Compared 8 paired sites. ORV use areas had significantly fewer species of vertebrates, reduced numbers of individuals and lower reptile and small mammal biomass. Censuses also showed decreased diversity, density, and biomass estimates of breeding birds in ORV used areas.

68. Bury, R. L. IMPACTS OF SNOWMOBILES ON WILDLIFE. Trans. N. Am. Wildl. Nat. Resour. Conf.; 43:149-156. 1978.
Existing research on snowmobile-wildlife interactions and future research needs are discussed (Boyle and Sampson 1983).

69. Bury, R. L. OFF-ROAD RECREATION VEHICLES: RESEARCH RESULTS AND ADMINISTRATIVE REPORTS, AND TECHNICAL ARTICLES, 1970-1975. Council of Planning Librarians, Monticello, Ill., Exch Biblio. 1067. 23 pp. 1976.
*Bibliography.

70. Bury, R. B. WHAT WE KNOW AND DO NOT KNOW ABOUT OFF-ROAD VEHICLE IMPACTS ON WILDLIFE. Page 110-122 in: R. N. L. Andrews; and P. F. Nowak, eds. Off-road vehicle use: A management challenge. Conf. Proc., 16-18 March 1980, Ann Arbor, MI. 1980.
Research concerning off-road vehicle impacts on wildlife is reviewed to illustrate the levels of impacts and to provide guidance for more effective protection of wildlife in off-road vehicle areas. Effects on wildlife include direct mortality, damage to vegetation, disruption of soil, and noise harassment. Research and management recommendations are suggested (Boyle and Sampson 1983).

71. Bury, R. L.; S. F. McCool; and R. J. Wendling. RESEARCH ON OFF-ROAD VEHICLES: A SUMMARY OF SELECTED REPORTS AND A COMPREHENSIVE BIBLIOGRAPHY. Pages 234-272, in: Proc. of the Southern States Recreation Research Applications Workshop, 15-18 September 1975, Asheville, NC. U.S. For, Serv. Gen. Tech. Rep. SE-9. 1976.
Bibliography.

72. Busnel, R. G. EFFECTS OF NOISE ON WILDLIFE: INTRODUCTION. Pages 7-22 in: J. L. Fletcher and R. G. Busnel. 1978.
This introductory article reviews some aspects of animal behavior associated with noise, citing examples from scientific literature and anecdotal observations. Theoretical approaches and aspects of policy relating to noise effects and the conservation of wildlife are discussed (Boyle and Sampson 1983).

73. Buss, I. O.; and A. S. Hawkins. *THE UPLAND PLOVER AT FAVILLE GROVE, WISCONSIN. Wilson Bull.; 51:202-220. 1939.

74. Butcher, D. SNOWMOBILES AND THE NATIONAL PARKS. Am For.; 78(4):28-31, 46-49. 1972.
The author cites Congressional testimony, popular literature, and personal experiences to document environmental impacts of snowmobiles, including impacts on wildlife. Habitat destruction and deliberate harassment of animals are noted. The author calls for the prohibition of snowmobiles and other off-road vehicles in National Parks to protect the environment and ensure the satisfaction of other park visitors (Boyle and Sampson 1983).

75. Cade, T. J.; J. H. Enderson; C. G. Thelander; and C. M. White. *PEREGRINE FALCON POPULATIONS: THEIR MANAGEMENT AND RECOVERY. The Peregrine Fund, Inc., Boise. 949 pp. 1988.

76. Call, M. W. HABITAT MANAGEMENT FOR BIRDS OF PREY. U.S.D.I; Bureau of Land Management, Tech. Note 338. 70pp. 1979.
Habitat management considerations for birds of prey are reviewed. Human activities that should be controlled in nesting and roosting areas include recreational activities; many areas preferred by humans for recreation are important raptor nesting sites as well. Management considerations include siting recreational developments away from important raptor habitats, and restricting human activities during the breeding season (Boyle and Sampson 1983).

77. Cannon, H. L. and J. M. Bowles. CONTAMINATION OF VEGETATION BY TETRAETHYL LEAD. Science 137:765-766. 1988.
Note: new.

78. Carbyn, L. N. WOLF POPULATION FLUCTUATIONS IN JASPER NATIONAL PARK, ALBERTA, CANADA. Biol. Consev.; 6(2):94-101. 1974.
Population fluctuations mainly a result of human pressures in areas adjacent to park. Population negatively affected by disturbance at den site and high percentage of ungulates on heavily traveled roads as wolves tend to avoid traveled roads.

79. Carbyn, L. N. *WOLF PREDATION OF ELK IN RIDING NATIONAL PARK, MANITOBA. J. Wildl. Manage.; 47(4):977-988. 1983.

80. Casey, D. *AMERICAN MARTEN. Dodd-Mead, New York. 64 pp. 1988.

81. Cassirer, E. F. RESPONSES OF ELK TO DISTURBANCE BY CROSS-COUNTRY SKIERS IN NORTHERN YELLOWSTONE NATIONAL PARK. M. S. Thesis, Univ. of Idaho, Moscow. 101 pp. 1990.
Note: new.

82. Cassirer, E. F.; D. J. Freddy; and E. D. Ables. ELK RESPONSES TO DISTURBANCE BY CROSS-COUNTRY SKIERS IN YELLOWSTONE NATIONAL PARK. Wildl. Soc. Bull.; 20:375-381. 1992.
The objectives of this study were to measure the immediate movements of elk when disturbed by cross-country skiers, to assess energy costs associated with these movements, and to identify factors that might influence elk behavior. The results of this disturbance study indicate that restricting cross-country skiers to locations > 650 m from elk wintering areas would probably minimize displacement of most nonhabituated elk by skiers on shrub steppe and upland steppe winter ranges similar to that in Yellowstone. Seventy-five percent of nonhabituated elk flight responses in northern Yellowstone occurred within 650 m. Skiers would likely have to remain at distances of >1,700 m to completely avoid disturbing elk. The amount of winter range used by skiers and the number of days involved seemed to be more important than skier numbers.

83. Chapman, R. C. THE EFFECTS OF HUMAN DISTURBANCE ON WOLVES. M.S. thesis; Univ. Alaska, Fairbanks 209 pp. 1977.
Wolves responded to humans near pups by barking or howling, leaving the area, or moving the pups. Low intensity disturbance does not seem to cause significant pup mortality. Recommends closing areas of 2.4 km radius around homesites to disturbance from 4 or 5 weeks before whelping until wolves leave the area. Contains appendix of more than 100 published and unpublished accounts of wolf/man interactions (Ream 1980).
84. Chappel, R. W. and R. J. Hudson. PREDICTION OF ENERGY EXPENDITURES BY ROCKY MOUNTAIN BIGHORN SHEEP. Can. J. Zool. 58:1908-1912. 1980.
Note: new.
85. Chester, J. M. HUMAN WILDLIFE INTERACTIONS IN THE GALLATIN RANGE, YELLOWSTONE NATIONAL PARK, 1973-1974. M.S. thesis; Montana State Univ., Bozeman. 114 pp. 1976.
Relationships between human use and the distribution, movements, and behavior of seven species of wildlife in the backcountry of the Gallatin Range, Yellowstone National Park, were investigated. Variation in the intensity of human use was rarely responsible for shifts in wildlife distribution. Wildlife belligerency towards humans was rare, although backcountry travelers tended to engage in activities that could increase detrimental encounters with wildlife (Boyle and Samson 1983).
86. Clark, T. W. *ANALYSIS OF PINE MARTEN POPULATION ORGANIZATION AND REGULATORY MECHANISMS IN JACKSON HOLE, WYOMING. Nat. Geogr. Soc. Research Report; 1982:131-143. 1982.
87. Clark, T. W.; E. Anderson; C. Douglas; and M. Strickland. *MARTES AMERICANA. Mammalian Species No. 289:1-8. 1987.
88. Clark, T. W.; A. H. Harvey, R. D. Dorn; D. L. Genter; and C. Groves, eds. RARE, SENSITIVE, AND THREATENED SPECIES OF THE GREATER YELLOWSTONE ECOSYSTEM. Northern Rockies Conservation Cooperative, Montana Natural Heritage Program, The Nature Conservancy, and Mountain West Environmental Services. 153 pp. 1989.
This report gives a description, range, habitat, life history and ecology, and conservation needs of each rare, sensitive, and threatened species (animal and plant) associated with the Greater Yellowstone Ecosystem (GYE).
89. Clark, T.; M. Bekoff; T. M. Campbell; and T. Hauptman. AMERICAN MARTEN, MARTES AMERICANA, HOME RANGES IN GRAND TETON NATIONAL PARK, WYOMING. Canadian Field-Nat.; 103(3):423-425. 1988.
90. Clevenger, G. A.; and G. W. Workman. THE EFFECTS OF CAMPGROUNDS ON SMALL MAMMALS IN CANYONLANDS AND ARCHES NATIONAL PARKS, UTAH. Trans. N. Am. Wildl. Nat. Resour. Conf.; 42:473-484. 1977.
Small mammal studies in 2 National Parks in Utah indicated that campgrounds may have significant effects on populations of small mammals inhabiting them. Additional food available at campgrounds may be partly responsible for larger populations observed in campgrounds (Boyle and Samson 1983).

91. Cole, D. N. and P. B. Landres. INDIRECT EFFECTS OF RECREATIONISTS ON WILDLIFE. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 183-202. Island Press, Washington, D.C. 1995.
Note: new.

92. Cole, D. L. and R. L. Knight. WILDLIFE PRESERVATION AND RECREATIONAL USE: CONFLICTING GOALS OF WILDLIFE MANAGEMENT. Tran. N. Am. Wildl. Nat. Res. Conf. 56:233-237. 1991.
Note: new.

93. Cole, David N. WILDERNESS RECREATION MANAGEMENT. J. For.; 91(2):224. 1993.

94. Cole, David L. WILDLIFE PRESERVATION AND RECREATIONAL USE:CONFLICTING GOALS OF WILDLIFE MANAGEMENT. Trans. N. Am. Wildl. Nat. Resour. Conf.; No. 5 p. 233-237. 1991.

95. Cole, G. F. GRIZZLY BEAR–ELK RELATIONSHIPS IN YELLOWSTONE NATIONAL PARK. J. Wildl. Mgmt. 36(2):556-561. 1972.
Note: new.

96. Connolly, G. E. *LIMITING FACTORS AND POPULATION REGULATION. Pages 245-285 in: O. A. Wallmo, ed. Mule and Black-tailed deer of North America. Univ. Neb. Press, Lincoln. 1981.

97. Connolly, G. E.; and D. C. Wallmo. *MANAGEMENT CHALLENGES AND OPPORTUNITIES. Pages 537-545 in: O. C. Wallmo, ed. Mule and black-tailed deer of North America. Univ. Neb. Press, Lincoln. 1981.

98. Conrad, A. H. WILDERNESS PRESERVATION, PLANNING AND MANAGEMENT: AN ANNOTATED BIBLIOGRAPHY. Council of Planning Librarians, Monticello, Ill., Exch. Biblio. 1515. 54 pp. 1978.
*Annotated Bibliography.

99. Cooke, A. S. OBSERVATIONS ON HOW CLOSE CERTAIN PASSERINE SPECIES WILL TOLERATE AN APPROACHING HUMAN IN RURAL AND SUBURBAN AREAS. Biological Conservation 18:85. 1980.
Note: new.

100. Corbet, P. S. SNOWMOBILES: FOR PLEASURE, PROFIT, AND POLLUTION. Ont. Nat.; 8(2):10-12. 1970.
Impacts of snowmobiles on urban and rural environments, including effects on wildlife, are discussed in this nontechnical article. Snowmobiles compact snow, changing the physical and thermal properties and thus potentially affecting animals that live beneath snow in winter. Deliberate harassment of wildlife by snowmobilers is uncommon but may be significant. Effective legislation and enforcement are needed to control the impacts of snowmobiles on the environment (Boyle and Samson 1983).

101. Corbus, M. MOOSE AS AN AESTHETIC RESOURCE AND THEIR SUMMER FEEDING BEHAVIOR. Am. Moose Conf. Workshop 8:244-273. 1972.
A moose herd in Sibley Provincial Park, Ontario, is described as an appreciative resource used by many campers who go there specifically to view moose. Responses of moose to the presence of humans and aspects of the resource users are discussed (Boyle and Samson 1983).

102. Craig, G. *PEREGRINE FALCON. Pages 807-826 in: Audubon Wildlife Report 1986. The National Audubon Society, Washington, D.C. 1986.

103. Craighead, F. C., Jr; and J. J. Craighead. DATA ON GRIZZLY BEAR DENNING ACTIVITIES AND BEHAVIOR OBTAINED BY WILDLIFE TELEMETRY. Pages 84-106 in: S. Herrero, ed. Bears—their biology and management, 6-9 November 1970, Calgary, Alberta. IUCN Publ. New Ser. 23, Morges, Switzerland. 1972.
Denning behavior of telemetered grizzly bears was studied in Yellowstone National Park. Observations suggested that grizzlies do not actively defend dens from other bears or humans if alternate courses of action are available. Most grizzlies apparently prefer to avoid humans; the most dangerous bears are those that have been wounded, sows with cubs, and those that have learned to associate food with humans (Boyle and Samson 1983).

104. Craighead, J. J., G. Atwell and B. W. O'Gara. ELK MIGRATIONS IN AND NEAR YELLOWSTONE NATIONAL PARK. Wildl. Monog. 29. 48 pp. 1972.
Note: new.

105. Craighead, J. J.; and F. C. Craighead, Jr. GRIZZLY BEAR-MAN RELATIONSHIPS IN YELLOWSTONE NATIONAL PARK. BioScience; 21:845-857. 1971.
Results are reported of 12 years of research on grizzly bears and their relationships with man in Yellowstone National Park and surrounding national forests. The chance for injury from grizzly bears is very small, but grizzly attacks provide exciting news and generate an exaggerated public response, which in turn may initiate over-reactionary bear control measures harmful to bear-human coexistence. Management must be carefully tailored to the facts of bear behavior, while visitors must be willing to accept a small risk (Boyle and Samson 1983).

106. Craighead, J. J.; J. R. Varney; and F. C. Craighead. *A POPULATION ANALYSIS OF THE YELLOWSTONE GRIZZLY BEARS. Mt. For. Cons. Exp. Sta. Bull.; No 40. 40 pp. 1974.

107. Cryer, M.; R. M. Ward; J. O. Stafford; and P. F. Randerson. DISTURBANCE OF OVERWINTERING WILDFOWL BY ANGLERS AT TWO RESEVOIR SITES IN SOUTH WALES. Bird Study; 34:191-199. 1987.

108. Curtis, S. HOW TO TRACK WILDLIFE ON SKIS. Backpacker 2(4):40-45, 79-80, 83. 1974.
Recommends techniques for approaching wildlife in winter for observation and photography. Warns of negative effects of disturbance on wintering wildlife. Cites snowmobile harassment of ungulates (Ream 1980).

109. Dahlgren, R. B.; and C. E. Korschgen. HUMAN DISTURBANCES OF WATERFOWL. USDI, U.S. Fish Wildl. Serv. Res. Pub. 188. 62 pp. 1992.
Annotated Bibliography.

110. Dalle-Molle, J.; and J. Van Horn. OBSERVATION OF VEHICLE TRAFFIC INTERFERING WITH MIGRATION OF DALL'S SHEEP, OVIS DALLI DALLI, IN DENALI NATIONAL PARK, ALASKA. Canadian Field-Nat.; 105(3):409-411.
Two observations of Dall's sheep groups unsuccessfully attempting to cross the Denali National Park Road, during a seasonal migration, are described. Where the road passes through sheep range, sheep have habituated to the traffic and readily cross. Sheep occupying ranges away from the road must cross the road during seasonal migrations and have not habituated to traffic, even though the road has been there for 54 years.

111. Daon, K. H. EFFECT OF SNOWMOBILES ON FISH AND WILDLIFE RESOURCES. Conv. Int. Assoc. Game Fish Conserv. Comm.; 60:97-103. 1970.
Increases in demand for snowmobiles and potential impacts on fish and wildlife resources are reviewed. Impacts of snowmobiles are listed as benefits and liabilities; other sections discuss registration, regulation, and education of snowmobile users (Boyle and Samson 1983).

112. Davy, B. A. and B. H. Sharp. CONTROL OF SNOWMOBILE NOISE. Environmental Protection Agency, Ofc. of Noise Abatement and Control. Springfield, VA. 1984.
Note: new.

113. DeForge, J. R. STRESS: IS IT LIMITING BIGHORN? Trans. Desert Bighorn Council; 20:30-31. 1976.
The bighorn sheep is an ice-age mammal that has become highly specialized, evolving essentially outside the influence of man. Today, however, human encroachment on sheep habitats and disturbance of populations result in stress in bighorns, forcing them to adapt socially. Stress, frequently human-induced, appears to be a major limiting factor in the bighorn's struggle for survival (Boyle and Samson 1983).

114. deGroot, R. W. TOURISM AND CONSERVATION IN THE GALAPAGOS. Biological Conservation 26:291-300. 1983.
Note: new.

115. Delgiudice, G. D.; F. J. Singer; and U. S. Seal. PHYSIOLOGICAL ASSESSMENT OF WINTER NUTRITIONAL DEPRIVATION IN ELK OF YELLOWSTONE NATIONAL PARK. J. Wildl. Manage.; 55(4):653-664. 1991.
During 13 January-29 March 1988, the authors assessed the extent of nutritional deprivation in cow elk groups on the lower, middle, and upper Northern Range and on the Madison-Firehole Range in Yellowstone National Park by 4 sequential collections and chemical analyses of urine excreted in snow (snow-urine). Throughout winter, snow-urine samples with metabolic profiles indicative of severe energy deprivation and accelerated degradation of lean body tissue were most apparent in areas associated with increased elk density and/or deep snow cover.

116. DeMarchi, R. REPORT AND RECOMMENDATIONS OF THE WORKSHOP ON CALIFORNIA BIGHORN SHEEP. Pages 143-163 in: J. B. Trefethen ed. The wild sheep in modern North America. Boone and Crockett Club and the Winchester Press, NY. 1975.
Objectives and procedures for management of California bighorn sheep for consumptive and nonconsumptive uses are described. Protection of bighorn sheep includes regulating off-road vehicles and human activities such as hiking, camping. picknicking, and sightseeing. Noncosumptive recreational uses of bighorn sheep are recognized as valuable and important criteria (Boyles and Samson 1983).

117. Denniston, R. H. ECOLOGY, BEHAVIOR AND POPULATION DYNAMICS OF THE WYOMING OR ROCKY MOUNTAIN MOOSE. Zoologica (NY); 41:105-118. 1956.
This report of ecological studies of moose in Wyoming includes sections on man-moose interactions. Moose were found to be tolerant of close observers when no quick motions or loud noises were made. Cases of moose aggression toward people and automobiles are noted (Boyle and Samson 1983).

118. Despain, D. D. Houston, M. Meagher, and P. Schullery. WILDLIFE IN TRANSITION: MAN AND NATURE ON YELLOWSTONE'S NORTHERN RANGE. Roberts Rinehart. Boulder, Colo. 142 pp. 1986.
Note: new.

119. Dice, E. F. EFFECTS OF SNOWMOBILING ON ALFALFA, TREES (PINUS RESINOSA, PINUS BANKSIANA) AND SOIL BACTERIA. Ext. Bull. Michigan State Coop. Ext. Serv. East Lansing, Mich. 1976.
Note: new.

120. Diem, K. L. WHITE PELICAN REPRODUCTIVE FAILURES IN THE MOLLY ISLANDS BREEDING COLONY IN YELLOWSTONE NATIONAL PARK. In: R. M. Linn, ed. Proc. of the 1st Conf. on Sci. Res. in the Nat. Parks. National Park Serv. Trans. and Proc. Series No. 5:489-496. 1979.

121. Diem, K. L.; and D. D. Condon. BANDING STUDIES OF WATERBIRDS ON THE MOLLY ISLANDS, YELLOWSTONE LAKE, WYOMING. Yellowstone Library and Museum Assoc., Yellowstone National Park, WY. 41 pp. 1967.

122. Dixon, K. R. and J. A. Chapman. HARMONIC MEAN MEASURE OF ANIMAL ACTIVITY AREAS. Ecology 6:1040-1044. 1980.
Note: new.

123. Doan, K. H. EFFECT OF SNOWMOBILES ON FISH AND WILDLIFE RESOURCES. Int. Assoc. Game Fish Conservation Commissioners Convention 60:97-103. New York. 1970.
Note: new.

124. Dorrance, M. J.; P. J. Savage; and D. E. Huff. EFFECTS OF SNOWMOBILES ON WHITE-TAILED DEER. J. Wildl. Manage.; 39(3):563-569. 1975.
In studies of white-tailed deer in Minnesota, deer responded to very low intensities of intrusion by man and snowmobiles. Displacement of deer from areas along trails occurred; in some cases changes in home range size and increased movement were observed. It is suggested that the observed disturbances could be detrimental to deer, especially during severe winters.

125. Douglas, C. W.; and M. A. Strickland. *FISHER. Pages 511-529 in: M. Novak, J. A. Baker, M. E. Obbard. and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario. 1987.

126. Drewien, R. C. *THE SANDHILL CRANE IN WYOMING. Wyoming Wildl.; 37(7):20-25. 1973.

127. Drewien, R. C.; and E. G. Bizeau. *STATUS AND DISTRIBUTION OF THE GREATER SANDHILL CRANE IN THE ROCKY MOUNTAINS. J. Wildl. Manage.; 38:720-742. 1974.

128. Drewien, R. C.; W. M. Brown; and J. D. Varley. THE GREATER SANDHILL CRANE IN YELLOWSTONE NATIONAL PARK: A PRELIMINARY SURVEY. Pages 27-38 in: J. C. Lewis and J. W. Ziewitz, eds. Proc. 1985 Crane Workshop. Platte River Whooping Crane Maintenance Trust and U.S, Fish and Wildlife Service, Grand Island, NE. 1987.

129. Driver, B. L. and P. J. Brown. THE OPPORTUNITY SPECTRUM CONCEPT AND BEHAVIORAL INFORMATION IN OUTDOOR RECREATION SUPPLY INVENTORIES: A RATIONALE. In: Integrated Inventories and Renewable Natural Resources. Proceedings of the Workshop, eds. Lund, H.G. et al., 24-31. General Tech. Report RM-55. Fort Collins, Colo. U.D. Dept. Agric., Forest. 1978.
Note: new.

130. Dufour, P. EFFECTS OF NOISE ON WILDLIFE AND OTHER ANIMALS. Memphis State University, for United States Environmental Protection Agency, NTID 300.5. 1971.
Note: new.
Data for domestic and laboratory animals was extrapolated for wildlife. Potential impacts included masking of signals and calls. Chronic exposure could result in physiological and behavioral changes. Effects would most likely be cumulative.

131. Dunaway, D. J. HUMAN DISTURBANCE AS A LIMITING FACTOR OF SIERRA NEVADA BIGHORN SHEEP. Trans. N. Am. Wild Sheep Conf.; 1:165-173. 1971.
Disturbance caused by human recreation is suggested as a factor limiting populations of bighorn sheep in California. Three populations that have declined were in areas of increased recreational use; two other stable populations have suffered less disturbance by recreationists (Boyle and Samson 1983).

132. Dunning, J. B., B. J. Danielson, and H. R. Pulliam. ECOLOGICAL PROCESSES THAT AFFECT POPULATIONS IN COMPLEX LANDSCAPES. Oikos 65:169-175. 1992.
Note: new.

133. Dunstan, T. C. THE BIOLOGY OF OSPREYS IN MINNESOTA. Loon; 45:108-113. 1973.
Results of 10 years of osprey research are summarized. While the effects of human disturbance to osprey productivity are difficult to evaluate, observations suggest that ospreys are sensitive to human interference, especially during incubation. Some nest abandonments have followed increased summer recreational use of the areas by boaters and fishermen (Boyle and Samson 1983).

134. Dunstan, T. C. BREEDING SUCCESS OF OSPREY IN MINNESOTA FROM 1963 TO 1968. Loon; 40:109-112. 1968.
The author reports results of his own studies plus observations gathered from several sources concerning osprey breeding success in Minnesota. Records indicate that human disturbance is a significant factor in reducing osprey productivity. Disturbances by direct shooting and by chilling or overheating of eggs when adults are frightened from nests are recorded (Boyle and Samson 1983).

135. Eckstein, R. G. and O. J. Rongstad. EFFECTS OF SNOWMOBILES ON THE MOVEMENTS OF WHITE-TAILED DEER IN NORTHERN WISCONSIN. Proc. Midwest Fish and Wildl. Conf. 35-39. 1973.
Note: new.

136. Eckstein, R. G.; T. F. O'Brien; O. J. Rongstad; and J. G. Bollinger. SNOWMOBILE EFFECTS ON MOVEMENTS OF WHITE-TAILED DEER: A CASE-STUDY. Environ. Conserv.; 6:45-51. 1979.
 Effects of snowmobiles on winter home ranges, movements, and activity patterns of white-tailed deer were studied in Wisconsin. Daily activity patterns, home range size, and habitat use were little affected by snowmobiles. the impact of snowmobiles on deer appears to be minimal, but routing trails away from deer concentration areas in winter is suggested (Boyle and Samson 1983).
137. Edge, W. D.; and C. L. Marcum. MOVEMENTS OF ELK IN RELATION TO LOGGING DISTURBANCES. J. Wildl. Manage.; 49(4):926-930. 1985.
 The objective of this study was to quantify the home ranges of nonmigratory cow elk, and to assess the effect of logging activities on home-range fidelity in the Chamerlain Creek area about 56 km east of Missoula, Montana. Results of the study indicate that cow elk will not abandon traditional home ranges because of logging activity when extensive areas of cover remain within their home range. Disturbances may alter habitat selection by increasing use of areas that provide cover, but this will occur within the traditional home range. In areas where cover is limited, logging activity may increase home-range size and reduce home-range fidelity. If closed areas are provided adjacent to all sides of active logging sales, disturbed home ranges will more likely contain security zones for elk. Logging activities that are restricted as much as possible in time and space, or conducted on seasonal ranges during when the elk are not present, will be least disruptive.
138. Edge, W. D.; C. L. Marcum; and S. L. Olson. EFFECTS OF LOGGING ACTIVITIES ON HOME-RANGE FIDELITY OF ELK. J. Wildl. Manage.; 49(3):741-744. 1985.
139. Edington, J. M.; and A. M. Edington. ECOLOGY, RECREATION AND TOURISM. Cambridge Univ. Press, Cambridge. 200 pp. 1986.
140. Elder, J. M. HUMAN INTERACTIONS WITH SIERRA NEVADA BIGHORN SHEEP: THE MOUNT BAXTER HERD. M.S. thesis; Univ. of Michigan, Ann Arbor. 93 pp. 1977.
 A project begun in 1976 studied human disturbance of bighorn sheep in California. Human use of the area included backpacking and climbing. Hikers camped in very limited areas associated with the trail, water, and trees; climbers had the greatest potential effects on sheep. the levels of intrusion did not appear to be adversely affecting sheep, but if the number is allowed to increase the effects on sheep should be closely monitored (Boyle and Samson 1983).
141. Elgmark, K. and A. Langeland. POLLUTED SNOW IN SOUTHERN NORWAY DURING WINTERS 1968-1971. Environ. Pollution 4:41-52. 1973.
 Note: new.
142. Enderson, J. H.; and J. Craig. STATUS OF THE PEREGRINE FALCON IN THE ROCKY MOUNTAINS. Auk; 91:727-736. 1974.
 Factors responsible for an apparent decline in the numbers of peregrine falcons in the central Rocky Mountains are discussed. Pesticides appear to be the major factor; human disturbances such as rock climbing, picknicking, and highways may be important locally but are not widespread enough to explain the general decline (Boyle and Samson 1983).

143. Enger, P. S., H. E. Karlsen, F. R. Knudsen, and O. Sand. DETECTION AND REACTION OF FISH TO INFRASOUND. ICES Marine Sciences Symposia 196:108-112. 1993.
Note: new.

144. Erlich, P. R. EXTINCTION: WHAT IS HAPPENING NOW AND WHAT NEEDS TO BE DONE. In: Dynamics of Extinction, D. K. Elliott, ed., pp. 157-164. John Wiley and Sons, New York. 1986.
Note: new.

145. Escherich, P. C.; and L. Blum, eds. *PROC. BOBCAT RESEARCH CONF. National Wildlife Federation Scientific and Technical Series 6, Washington, D.C. 1979.

146. Evans, D. L. *STATUS REPORTS ON TWELVE RAPTORS. USDI, U.S. Fish Wildl. Serv. Special Sci. Rep. No. 238, Washington, D.C. 68 pp. 1982.

147. Fahrig, L. and G. Merriam. HABITAT PATCH CONNECTIVITY AND POPULATION SURVIVAL. Ecology 66:1762-1768. 1985.
Note: new.

148. Fancy, S. G.; and R. G. White. ENERGY EXPENDITURES BY CARIBOU WHILE CRATERING IN SNOW. J. Wildl. Manage.; 49(4):987-993. 1985.
The rate of energy expenditure by caribou digging in snow for lichens was determined by heart rate telemetry and an analysis of cratering mechanics. Based on a significant linear relationship between energy expenditure and heart rate, the mean cost per digging stroke in light, uncrusted snow was 118 J, whereas in denser (0.36 g/sq.cm) snow with a thin, hard crust the mean cost was 219 J/stroke. The cost of cratering through snow compacted by a snowmobile was 481 J/stoke. A comparison of metabolic and mechanical energy required for cratering suggested that caribou have evolved an energetically-efficient mechanism for obtaining food from beneath the snow layer.

149. Fay, R. R. HEARING IN VERTEBRATES: A PSYCHOPHYSICS DATABOOK. Hill-Fay Associates. Winnetka, Ill. 621 pp. 1988.
Note: new.

150. Fenton, M. B.; and G. P. Bell. *ECHOLOCATION AND FEEDING BEHAVIOR OF FOUR SPECIES OF MYOTIS (CHIROPTERA). Can. J. Zool.; 57:1271-1277. 1979.

151. Ferguson, M. A. D. and L. B. Keith. INFLUENCE OF NORDIC SKIING ON DISTRIBUTION OF MOOSE AND ELK IN ELK ISLAND NATIONAL PARK, ALBERTA. Can. Field-Nat. 99:69-78. 1982.
Note: new.

152. Ferguson, M. A.; and L. B. Keith. INTERACTIONS OF NORDIC SKIERS WITH UNGULATES IN ELK ISLAND NATIONAL PARK. Alberta Fish Wildl. Div. Wildl. Tech. Bull.; No. 6 31pp. 1981.

153. Fernandez, C.; and P. Azkona. HUMAN DISTURBANCE AFFECTS PARENTAL CARE OF MARSH HARRIERS AND NUTRITIONAL STATUS OF NESTLINGS. J. Wildl. Manage.; 57(3):602-608. 1993.
The authors studied the effects of human disturbance on parental care by marsh harriers (Cirus aeruginosus) in spring 1991 at Dos Reinos Lake, Ebro Valley, Spain. They assessed changes in reproductive activities and nutritional condition of nestlings due to low-level human disturbance during incubation and nestling phases. The number of food items delivered and the time spent by males and females in the nesting area and on the nest decreased during disturbed periods, especially during incubation, whereas behaviors related to stress (alarm calls, chases against other intruding birds, and percentage flying time) increased. Although annual productivity of the disturbed pairs was not affected, nestlings of disturbed birds exhibited levels of blood urea that were higher than those of undisturbed pairs. Thus, minor human disturbances may cause long-term effects on lifetime reproductive success of birds by increasing energy and time expenditure in non-reproductive activities and by reducing condition of nestlings.

154. Ferrin, R. S. and G. P. Coltharp. LEAD EMISSIONS FROM SNOWMOBILES AS A FACTOR IN LEAD CONTAMINATION OF SNOW. Proceedings of the Utah Academy of Science, Arts and Letters 51(1):116-118. 1974.
Note: new.

155. Findholt, S. L. STATUS AND DISTRIBUTION OF HERONS, EGRETS, IBISES AND RELATED SPECIES IN WYOMING. Colonial Waterbirds; 7:55-62. 1984.

156. Findholt, S. L.; and K. L. Diem. STATUS AND DISTRIBUTION OF AMERICAN WHITE PELICAN COLONIES IN WYOMING: AN UPDATE. Great Basin Nat.; 48:285-289. 1988.

157. Findholt, S. L.; and K. L. Berger. UPDATE ON THE STATUS AND DISTRIBUTION OF COLONIALLY NESTING WATERBIRDS IN WYOMING. Nongame Special Report, Wyoming Game and Fish Dept. 40 pp. 1987.

158. Fitts-Cochrane, J. LONG-BILLED CURLEW HABITAT AND LAND USE RELATIONSHIPS IN WESTERN WYOMING. M.S. thesis; Univ. Wyo., Laramie. 136 pp. 1983.

159. Fletcher, J. L. and R. G. Busnel, eds. EFFECTS OF NOISE ON WILDLIFE. Academic Press, Inc., New York. 1978.
Note: new.
Several papers, including a symposium on the effects on wildlife, quantifying the acoustic dose when determining the effects of noise on wildlife, and a perspective of government and public policy regarding noise and animals.

160. Foin, T. C., E. O. Garton, C. W. Bowen, J. M. Everingham, R. O. Schultz, and B. Holton, Jr. QUANTITATIVE STUDIES OF VISITOR IMPACTS ON ENVIRONMENTS OF YOSEMITE NATIONAL PARK, CALIFORNIA, AND THEIR IMPLICATIONS FOR PARK MANAGEMENT POLICY. Journal of Environmental Management 5:1-22. 1977.
Note: new.

161. Foresman, C. L., D. K. Ryerson, R. F. Johannes, W. H. Paulson, R. E. Rand, G. H. Tenpas, D. A. Schlough, and J. W. Pendleton. EFFECTS OF SNOWMOBILE TRAFFIC ON NON-FOREST VEGETATION: SECOND REPORT. School of Natural Resources, Univ. of Wisconsin, Madison, Wisc. 1973.
Note: new.

162. Foresman, K. R. *SOREX HOYI IN IDAHO: A NEW STATE RECORD. Murrelet; 67:81-82. 1987.

163. Franklin, A. B. *BREEDING BIOLOGY OF THE GREAT GRAY OWL IN SOUTH-EASTERN IDAHO AND NORTHWESTERN WYOMING. Condor: 90:689-696. 1988.

164. Fraser, J. D.; L. D. Frenzel; and J. E. Mathisen. THE IMPACT OF HUMAN ACTIVITIES ON BREEDING BALD EAGLES IN NORTH-CENTRAL ILLINOIS. J. Wildl. Manage.; 49:585-592. 1985.

165. Fraser, J. D.; L. D. Frenzell; and J. E. Mathisen. THE IMPACT OF HUMAN ACTIVITIES ON BREEDING BALD EAGLES IN NORTH-CENTRAL MINNESOTA. J. Wildl. Manage.; 49(3):585-592. 1985.

The impacts of human activities and eagle management practices on bald eagle nesting biology were studied on Chippewa National forest in north-central Minnesota. Nests built on developed shoreline were farther away from water than nests built on undeveloped shoreline. Breeding eagles flushed at 57-991 m at the approach of a pedestrian. Fixed-wing aircraft passing 20-200 m from nests did not flush incubating or brooding eagles. The authors found no evidence that, under present management policies, human activities have an important impact on bald eagle reproductive success on the Chippewa National Forest.

166. Freddy, D. J. DEER-ELK INVESTIGATIONS: SNOWMOBILE HARASSMENT OF MULE DEER ON COLD WINTER RANGES. Colo. Div. Wildl Project W-038-R-32/WP14/J11. 15 pp. 1977.

Two semi-tame telemetered mule deer were experimentally harassed by one person, two persons, person plus a dog, and a snowmobile at various distances. Deer reactions to harassment were noted. Heart rate measured by telemetery was found to be sensitive measure of disturbance (Boyle and Samson 1983).

167. Freddy, D. J.; W. M. Bronaugh; and M. C. Fowler. RESPONSES OF MULE DEER TO DISTURBANCE BY PERSONS AFOOT AND SNOWMOBILES. Wildl. Soc. Bull.; 14:63-68. 1986.

The objectives of this study in north-central Colorado were to compare overt behavioral responses of adult female mule deer reacting to persons afoot or snowmobiles during controlled disturbance trials and to monitor their survival and fecundity. The tendency for flight distances to increase when deer exhibited multiple flight responses to persons afoot suggested that deer did not readily habituate to disturbance and these responses were longer in duration, involved running more frequently, and were greater in estimated energy expenditure. Minimizing all responses by deer would require persons afoot and snowmobiles to remain >334 m and > 470 m from deer, respectively. The authors concluded that their disturbance study did not markedly affect the mortality or fecundity of adult female deer.

168. French, J. M.; and J. R. Koplin. DISTRIBUTION, ABUNDANCE, AND BREEDING STATUS OF OSPREYS IN NORTHWESTERN CALIFORNIA. Pages 223-240 in: J. C. Ogden, ed. Trans. of the N. Am. Osprey Res. Conf.; 10-12 February 1972, Williamsburg, VA. U.S. Natl. Park Serv. Trans. Proc. Ser. 2. 1972.
Data are presented concerning abundance and reproduction of ospreys in California. Factors influencing fledgling productivity are discussed, including human disturbance. Logging and shooting were found to seriously affect nesting ospreys, but there was no indication that recreational activities including sightseeing, camping, fishing, and swimming were detrimental to breeding success of ospreys (Boyle and Samson 1983).

169. Fyfe, R. THE PEREGRINE FALCON IN NORTHERN CANADA. Pages 101-114 in: J. J. Hickey, ed. Peregrine falcon populations: their biology and decline. Univ. of Wisconsin Press, Madison. 1969.
Recent evidence suggests that the peregrine remains a common breeding bird in northern Canada, although a local decline was attributed to human disturbance. Human interference with peregrines near northern settlements is a possible deciminating factor.

170. Gabrielsen, G. W. and E. N. Smith. PHYSIOLOGICAL RESPONSES OF WILDLIFE TO DISTURBANCE. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 95-107. Island Press, Washington, D.C. 1995.
Note: new.

171. Garber, D. P. OSPREY NESTING ECOLOGY IN LASSEN AND PLUMAS COUNTIES, CALIFORNIA. M.S. thesis; Humboldt State Univ., Arcata. CA. 59 pp. 1972.
Nesting efforts of ospreys were studied in northwestern California. Major cases of nesting failure was high winds and eggshell breakage, but human disturbance was responsible for 33% of observed egg losses. In one case, campers caused adult osprey to abandon a nest with eggs. During fledgling counts young ospreys sometimes flew from nests, apparently for the first time. Such early flights may increase the incidence of injury and predation of fledglings (Boyle and Samson 1983).

172. Garrott, R. A., G. White, R. M. Bartman, L. H. Carpenter, and A. W. Alldredge. MOVEMENTS OF FEMALE MULE DEER IN NORTHWEST COLORADO. Journal of Wildl. Mgmt. 51(3). 1987.
Note: new.
Migration was strongly correlated to winter severity. Demonstrated strong fidelity to summer and winter ranges. Fidelity of individual movement patterns is long term, possibly for life.

173. Garton, E. O.; C. W. Bowen; and T. C. Foin, Jr. THE IMPACT OF VISITORS ON SMALL MAMMAL COMMUNITIES OF YOSEMITE NATIONAL PARK. Pages 44-50 in: T. C. Foin, Jr. ed. Visitor impacts on National Parks: The Yosemite ecological impact study. Univ. California, Davis, Inst. Ecol. Pupl. 10. 1977.
Visitor use of meadow and forest sites in Yosemite National Park was related to the distribution and abundance of small mammals. Deer mouse populations apparently increase in response to human use of forested areas, while mountain vole populations showed no relationship to human use except for gross habitat alterations such as meadow draining. Data for other small mammals were insufficient to determine relationships with human use (Boyle and Samson 1983).

174. Gasoway, W. C.; R. O. Peterson; J. L. Davis; P. E. K. Shepard; and O. E. Burns. *INTERRELATIONSHIPS OF WOLVES, PREY, AND MAN IN INTERIOR ALASKA. Wildl. Monogr. No. 84. 50 pp. 1983.

175. Gavrin, V. F. EFFECT OF ANXIETY FACTOR ON GAME FOWL PRODUCTIVITY. Pages 401-403 in: I. Kjerner and P. Bjurholm, eds. Proc. XIth Int. Cong. of Game Biologists, 3-7 September 1973, Stockholm, Sweden. National Swedish Environmental Protection Board, Stockholm. 1974.
Effects of stress on waterfowl and grouse was studied in the USSR. Recreational activities in bird habitats disturb daily activity patterns and alter the behavior of birds. Disturbance causes additional predation pressures and losses of young to starvation; disrupted timing of breeding lowers female fertility and increases the number of inferior birds in the population (Boyle and Samson 1983).

176. Geist, V. A BEHAVIORAL APPROACH TO THE MANAGEMENT OF WILD UNGULATES. Pages 413-424 in: E. Duffy and A. S. Watts, eds. The scientific management of animal and plant communities for conservation. Symp. British Ecol. Soc. 11. Blackwell Sci. Publ., Oxford. 1971.

177. Geist, V. BEHAVIOR. In: Big Game of North America: Ecology and Management, J. L. Schmidt and D. C. Gilbert, eds., pp 283-296. Stackpole Books. Harrisburg, Penn. 494 pp. 1978.
Note: new.

178. Geist, V. BIGHORN SHEEP ECOLOGY. Wildl. Soc. News; 136:61. 1971.
In a letter to the editor, the author explains physiological and energetic concerns related to increased activity of bighorn sheep following removal of old rams from populations. Harassment of sheep and other animals by a combination of hunting and hiking/wildlife viewing may be fatal to sheep (Boyle and Samson 1983).

179. Geist, V. HARRASSMENT OF LARGE MAMMALS AND BIRDS: WITH A CRITIQUE OF THE RESEARCH SUBMITTED BY ARCTIC GAS STUDY LTD. ON THIS SUBJECT. Report to the Berger Commission 64pp. 1975.

180. Geist, V. IS BIG GAME HARASSMENT HARMFUL? Oilweek; 22(17):12-13. 1971.
Harassment of North American big game is considered in terms of animal energy budgets and physical damage. Energy “costs” of harassment are calculated as energy expended above and beyond normal daily expenditures. Chronic harassment may result in reduced reproductive rates and increased mortality (Boyle and Samson 1983).

181. Geist, V. ON THE BEHAVIOR OF THE NORTH AMERICAN MOOSE IN BRITISH COLUMBIA. Behavior; 20:377-416. 1963.
Calf and yearling moose are sometimes quite tame when adults are absent. The sight of man at close range causes most animals to run; however, there is considerable variation among individual moose. Cites case where moose did not take flight even when one of the group was shot. Intense feeding often occurs after disturbance has passed (Ream 1980).

182. Genter, D. l. *STATUS OF THE SPOTTED BAT (EUDERMA MACULATUM) IN THE PRYOR MOUNTAINS OF SOUTHCENTRAL MONTANA. Report to USDA, U.S. For. Serv., Custer National Forest, Billings. 17 pp. 1988.

183. Genter, D. L.; and L. H. Metzgar. *SURVEY OF THE BAT SPECIES AND THEIR HABITAT USE IN GRAND TETON NATIONAL PARK. Page 65-69 in: Wyoming-National Park Service Research Center, 9th Annual Report. 1985.
184. Gentor, D. L. *WINTERING BATS OF THE UPPER SNAKE RIVER PLAIN: OCCURENCE IN LAVA TUBE CAVES. Great Plains Nat.; 46:241-244. 1986.
185. George, J. L.; C. E. Braun; R. A. Ryder and E. Decker. RESPONSE OF WATERBIRDS TO EXPERIMENTAL DISTURBANCES. Proc. Issues Technol. Manage. Wildl. (Thorne Ecol. Inst.); No. 5, pp. 52-59. 1991.
186. Gerrard, J. M.; and G. R. Bortolotti. *THE BALD EAGLE: HAUNTS AND HABITS OF A WILDERNESS MONARCH. Smithsonian Institution Press, Washington, D.C. 177 pp. 1988.
187. Gese, E. M.; O. J. Rongstad; and W. R. Mytton. CHANGES IN COYOTE MOVEMENTS DUE TO MILITARY ACTIVITY. J. Wildl. Manage.; 53(2):334-339. 1989.
The authors investigated the response of coyotes to military activity on the Pinon Canyon Maneuver Site, Colorado, during 1984-86. Sixteen coyotes responded to military activity by expanding, contracting, abandoning, or not changing their home range during military maneuvers compared to before and after maneuvers. Three coyote abandoned their home ranges, with 1 animal returning to its original home range 1 week after maneuvers. Most coyotes that expanded their ranges during military maneuvers resumed their original home range after military maneuvers ceased. Responses appeared to be related to the amount of available cover, topography, and intensity of military activity in a coyote's home range. Coyote activity patterns during the day increased, while activity at sunrise, sunset, and night remained the same during military activity.
188. Gilpin, M. E. SPATIAL STRUCTURE AND POPULATION VIABILITY. In: Viable Populations for Conservation, M. E. Soule, ed., pp. 124-139. Cambridge University Press. 1987.
Note: new.
189. Gipson, P. S. ABORTION AND CONSUMPTION OF FETUSES BY COYOTES FOLLOWING ABNORMAL STRESS. Southwestern Naturalist 21:558-559. 1970.
Note: new.
190. Glinski, R. L. BIRDWATCHING ETIQUTTE: THE NEED FOR A DEVELOPING PHILOSOPY. Am. Bird; 30:655-657. 1976.
Examples of disturbance to nongame birds by bird watchers are used to indicate a need to manage bird watching. Disturbance can cause lowered survival and reproduction of birds due to increased energy expenditures, behavior alteration, abandonment of nests, or loss of eggs and young to chilling, overheating, or predation. A behavioral code for bird watchers is proposed to regulate personal activities (Boyle and Samson 1983).
191. Goldsmith, F. B. ECOLOGICAL EFFECTS OF VISITORS IN THE COUNTRYSIDE. Pages 217-231 in: A. Warren and F. B. Goldsmith, eds. Conservation in practice. Wiley and Sons, London. 1974.
Ecological effects of recreation are reviewed, including impacts on wildlife. Sections discuss carrying capacity, characteristics of ecosystems, succession, visitor distribution, effects of trampling, direct research on ecological effects of recreation, and management (Boyle and Samson 1983).

192. Gooders, J. WILDLIFE AND TOURISM. Birds Int.; 1:21-23, 27. 1975.
Wildlife tourism is described as a modern and expanding business. Direct and indirect benefits of tourism to wildlife conservation are contrasted with impacts including disturbance to wildlife. The author suggests that tourism will continue to expand, and that steps should be taken to minimize disturbances to wildlife (Boyle and Samson 1983).
193. Goodrich, J. M.; and J. Berger. WINTER RECREATION AND HIBERNATING BLACK BEARS URSUS AMERICANUS. Biol. Conserv.; 67(2): 105-110. 1994.
194. Goodson, N. J. STATUS OF BIGHORN SHEEP IN ROCKY MOUNTAIN NATIONAL PARK. M.S. thesis; Colorado State Univ., Fort Collins. 190 pp. 1978.
During studies of bighorn sheep in Rocky Mountain National Park, Colorado, sheep interactions with people were noted. In areas where sheep were accustomed to seeing people, they tolerated people if approached gradually and not too closely; however, on several occasions sheep were driven from feeding areas or mineral licks by visitors. Sheep in backcountry areas were more wary (Boyle and Samson 1983).
195. Graefe, A. R., F. R. Kruss, and J. J. Vaske. VISITOR IMPACT MANAGEMENT: THE PLANNING FRAMEWORK. National Parks and Conservation Association. Washington, D.C. 105 pp. 1990.
Note: new.
196. Graefe, A. R., F. R. Krass, and J. J. Vaske. VISITOR IMPACT MANAGEMENT. Vols. I and II. National Parks and Conservation Association. Washington, D.C. 1990.
Note: new.
197. Graham, H. ENVIRONMENTAL ANALYSIS PROCEDURES FOR BIGHORN IN THE SAN GABRIEL MOUNTAINS. Trans. Desert Bighorn Counc.; 15:38-45. 1971.
Graphic analysis was used to evaluate bighorn habitat in California. Human use impacts were portrayed on overlays and compared to bighorn distributions and other habitat characteristics. Human recreational use has caused sheep to avoid certain areas. Light use has little effect on sheep distributions, but heavier use (500-900 visitor-days per summer season) causes bighorns to move from their historic range (Boyle and Samson 1983).
198. Graham, H. THE IMPACT OF MODERN MAN. Pages 288-309 in: G. Monson and L. Sumner, eds. The desert bighorn: Its life history, ecology, and management. Univ. of Arizona Press, Tucson. 1980.
The history of man’s relationship with bighorn sheep and current impacts of man on sheep are reviewed. Effects of hiking, horseback riding, motor vehicles, motorboats, ski lifts and tramways, aircraft, noises, and dogs are discussed. Human-caused habitat alterations are related to tolerance of sheep to intrusions (Boyle and Samson 1983).
199. Graham, H. MULTIPLE USE COORDINATION ON THE SAN GORGONIO BIGHORN UNIT. Trans. Desert Bighorn Counc.; 10:71-77. 1966.
Multiple use management of a California national forest area containing bighorn sheep is discussed. The authors explains the rationale and methodology of multiple use, and describes various land uses and their coordination with bighorn management. Proposals for massive recreational developments have been rejected because of perceived incompatibility with preservation of key bighorn habitats (Boyle and Samson 1983).

200. Graul, W. D. *ADAPTIVE ASPECTS OF THE MOUNTAIN PLOVER SOCIAL SYSTEM. Living Bird; 12:69-94. 1973.

201. Graul, W. D. *BREEDING BIOLOGY OF THE MOUNTAIN PLOVER. Wilson Bull.; 87:6-31. 1975.

202. Graul, W. D. and G. C. Miller. STRENGTHENING ECOSYSTEM MANAGEMENT APPROACHES. Wildl. Soc. Bull. 12:282-289. 1984.
Note: new.

203. Graul, W. D.; and L. E. Webster. *BREEDING STATUS OF THE MOUNTAIN PLOVER. Condor; 78:265-267. 1976.

204. Gray, J. R. KINDS AND COSTS OF RECREATIONAL POLLUTION IN THE SANDIA MOUNTAINS. New Mexico State Univ., Las Cruces, Agric. Exp. Sta. Bull. 651. 57 pp. 1977.
Environmental costs of recreation in the Sandia Mountains, New Mexico, were quantified by surveying recreationists, identifying associated pollutants and environmental impacts, and calculating costs of their control. Wildlife harassment, primary by hikers, was among impacts that tended to restrict activities most in a cost analysis model. Nature study and hunter groups were determined as having the highest cost per hour (Boyle and Samson 1983).

205. Gray, J. A. PSYCHOLOGY OF FEAR AND STRESS, 2ND ED. Cambridge University Press. New York. 1987.
Note: new.

206. Greater Yellowstone Coordinating Committee. AN AGGREGATION OF NATIONAL PARK AND NATIONAL FOREST MANAGEMENT PLANS. A cooperative project of the NPS and NFS. 1987.

207. Greater Yellowstone Bald Eagle Working Team. A BALD EAGLE MANAGEMENT PLAN FOR THE GREATER YELLOWSTONE ECOSYSTEM. Wyoming Game and Fish Dept., Cheyenne. 82 pp. 1983.

208. Greater Yellowstone Bald Eagle Working Team. SIX-YEAR SUMMARY PRODUCTION REPORT FOR THE GREATER YELLOWSTONE ECOSYSTEM. Compiled and edited by Bob Jones and Russ McFarling, U.S. Bur. Land Manage., Idaho Falls, ID. 1989.

209. Greer, T. ENVIRONMENTAL IMPACT OF SNOWMOBILES: A REVIEW OF THE LITERATURE. Univ. of Oregon, Portland. 1979.
Note: new.

210. Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. AN ECOSYSTEM PERSPECTIVE OF RIPARIAN ZONES. BioScience 41:540-551. 1991.
Note: new.

211. Greller, A. M., et al. SNOWMOBILE IMPACT ON THREE ALPINE TUNDRA PLANT COMMUNITIES. Environmental Conservation 1(2):101-110. 1974.
Note: new.

212. Grier, J. W.; J. B. Elder; F. J. Gramlich; N. F. Green; J. V. Kussman; J. E. Mathisen; and J. P. Mattsson. NORTHERN STATES BALD EAGLE RECOVERY PLAN. USDI; Fish and Wildlife Service. 1983.

213. Groves, C. R. *DISTRIBUTION OF THE WOLVERINE IN IDAHO AS DETERMINED BY MAIL QUESTIONNAIRE. Northw. Sci.; 62(4):181-185. 1988.

214. Grubb, T. G.; and R. M. King. ASSESSING HUMAN DISTURBANCE OF BREEDING BALD EAGLES WITH CLASSIFICATION TREE MODELS. J. Wildl. Manage.; 55(3):500-511. 1991.

The researchers recorded 4,188 events of human activity and associated bald eagle response in the vicinity of 13 central Arizona nest sites during 1983-1985. A hierarchical classification of 9 dependent parameters and 3 independent parameters was developed to quantify pedestrian, aquatic, vehicle, noise (gunshot/sonic boom), and aircraft disturbance groups. Type and frequency of response varied inversely with the distance from an eagle to the disturbance. Bald eagles were more often flushed from perches than nests and were most easily disturbed when foraging. Pedestrian was the most disturbing human activity, whereas aircraft was the least. A classification tree (CART) model was developed for pooled and group disturbances to evaluate response severity and to formulate disturbance-specific management criteria. The CART models ranked distance to disturbance as the most important classifier of eagle response, followed in decreasing order of discriminatory value by duration of disturbance, visibility, number of units per event, position relative to affected eagle, and sound. This procedure offers improved specificity in human disturbance assessment.

215. Grubb, T. G.; W. W. Bowereman; J. P. Geisy; and G. A. Dawson. REPONSES OF BREEDING BALD EAGLES, HALIAEETUS LEUCOCEPHALIS, TO HUMAN ACTIVITIES IN NORTHCENTRAL MICHIGAN. Canadian Field-Nat.; 106(4):443-453. 1992.

The authors recorded 714 events of potentially disturbing human activity near six pairs of Bald Eagles breeding in northcental Michigan in 1990. Vehicles and pedestrians elicited the highest response frequencies, but aircraft and aquatic activities were the most common. Magnitude of response was inversely proportional to median distance-to-disturbance. Seventy-five percent of all alert and flight responses occurred when activity was within 500m and 200m, respectively. Adults responded more frequently than nestlings, and at greater distance-to-disturbance when perched away from nests. May was the peak month for human activity, most of which occurred on weekends (60%) and afternoon (72%). Classification tree (CART) models are used to assess disturbance-specific response frequencies and to formulate management considerations.

216. Guth, R. W. FOREST AND CAMPGROUND BIRD COMMUNITIES OF PENINSULA STATE PARK, WISCONSIN. Passenger Pigeon; 40:489-493. 1978.

A study in Door County, Wisconsin, compared bird populations of mature forests, forest edge, and altered campground sites. Bird density and species diversity were least in forest sites, and greatest in campgrounds. Birds in campgrounds represented a greater percentage of common and widespread species, whereas several rare forest species were absent (Boyle and Samson 1983).

217. Guth, R. W. THE JUNK FOOD GUILD: BIRDS AND MAMMALS ON PICNIC GROUNDS AND IN RESIDENTIAL AREAS. Ill. Audubon Bull.; 189:3-7. 1979.

Birds and mammals of the junk food guild benefit from human recreation by finding scraps of food in picnic grounds of parks and forest preserves. Experiments in urban areas near Chicago, Illinois, revealed aspects of foraging behavior and food selection by residential area birds (Boyle and Samson 1983).

218. Gutzwiller, K. J. ASSESSING RECREATIONAL IMPACTS ON WILDLIFE: THE VALUE AND DESIGN OF EXPERIMENTS. Trans. N. Am. Wildl. Nat. Res. Conf.; 56:248-255. 1991.

219. Gutzwiller, K. J. RECREATIONAL DISTURBANCE AND WILDLIFE COMMUNITIES. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 169-181. Island Press, Washington, D.C. 1995.
Note: new.

220. Gutzwiller, K. J. RECREATIONAL DISTURBANCE AND WILDLIFE COMMUNITIES. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 169-181. Island Press. Washington, D.C. 1995.
Note: new.

221. Gutzwiller, K. J. SERIAL MANAGEMENT EXPERIMENTS: AN ADAPTIVE APPROACH TO REDUCE RECREATIONAL IMPACTS ON WILDLIFE. Trans. N. Am. Wildl. and Nat. Resour. Conf.; 58:528-536. 1993.

222. Haber, G. C. EIGHT YEARS OF WOLF RESEARCH AT MCKINLEY PARK. Alaska; 39(4):43-45, 59, 53-56. 1973.
These popular articles summarize research results and observations concerning wolves in Mount McKinley National Park, Alaska. Wolf social systems, behavior, and relationships to prey species and humans are discussed.

223. Hagen, A. and A. Langeland. POLLUTED SNOW IN SOUTHERN NORWAY AND THE EFFECT OF THE MELTWATER ON FRESHWATER AND AQUATIC ORGANISMS. Environ. Pollution 5:45-57. 1973.
Note: new.

224. Haines, H. E. J. SNOWMOBILES IN YELLOWSTONE: BIOMASS ALTERNATIVES TO REDUCE POLLUTION. Montana Dept. of Environmental Quality. Survey of Visitor Impact on Wildlife. Curtis Canyon Area, National Elk Refuge, Jackson, Wyo. 1984.
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Factors affecting the quality of wildlife viewing for 384 visitors to Cades Cove, Great Smoky Mountains National Park, were surveyed. Wildlife visibility potential, visual encounters with wildlife, visitor expectation and preference standard toward visual encounters, importance of type and number of animals seen, and viewer behavior were regressed on quality of wildlife viewing during an 18 km auto tour. Respondents rated quality of viewing high, with most visitors seeing 5 or more types of wildlife, and nearly everyone seeing white-tailed deer. Expectations toward the variety and total numbers of animals seen, preference standards toward seeing black bears, and the viewing behaviors of stopping the car and using binoculars to enhance viewing were the best predictors of a quality wildlife viewing experience.

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Broad problem areas and specific questions about human behavior aspects of wildlife management are identified. Research should be directed toward various aspects of hunter behavior, nonconsumptive uses of wildlife, wildlife economics, and political-legal issues. As nonconsumptive use of wildlife increases, managers are challenged to both gain support from and supply satisfaction to appreciative users (Boyle and Samson 1983).

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245. Henry, W. RELATIONSHIPS BETWEEN VISITOR USE AND CAPACITY FOR KENYA’S AMBOSELI NATIONAL PARK. Ph.D. Dissertation. Fort Collins, Colorado: Colorado State University. 1980.
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Direct observations, pellet transects, and hiker interviews were used to assess use overlap and nature of interactions between humans and bighorn sheep in California. Distance, juxtaposition, and herd size and composition were important factors in reaction of sheep to humans. Bighorn-human encounters were not adversely affecting the bighorn population; nevertheless, limitation of human use of the study area is recommended (Boyle and Samson 1983).

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The authors measured the flushing responses and flushing distances of 6 species of diurnal raptors (American kestrels, merlins, prairie falcons, rough-legged hawks, ferruginous hawks, and golden eagles) exposed to walking and vehicle disturbances during winter in northern Colorado. Walking disturbances resulted in more flushes than vehicle disturbances for all species except prairie falcons. Although flush distance did not vary with disturbance type for the three falcon species, rough-legged hawks and golden eagles flushed at greater distances for walking disturbances and ferruginous hawks flushed at greater distances for vehicle disturbances. Merlins and prairie falcons perched along paved roads had shorter flush distances to walking disturbances than individuals perched along gravel roads. Rough-legged hawks perched nearer to the road flushed at greater distances than those farther away. American kestral, prairie falcons, and ferruginous hawks perched closer to the ground had greater flush distances than those perched higher. Dark-morph ferruginous and rough-legged hawks flushed at greater distances than light morphs. For walking disturbances, a linear relationship existed between flight distance and body mass, with lighter species flushing at shorter distances; however, this trend did not hold for vehicle disturbances.

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Behavior of mountain goats in British Columbia is described, including reactions to man. Goat responses to human presence varied according to season, herd size, and other circumstances. Goats were rarely aggressive toward the author, although two incidents are described in which a goat appeared to threaten him (Boyle and Samson 1983).

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In a study of raven nesting habitats in Virginia, relationships of nesting ravens in response to human pressure was variable depending on the situation. Human activity should be restricted near active nests, despite the observed tenacity of some nesting pairs. Most birds would not be affected by recreation activity farther than 200 meters from nests (Boyle and Samson 1983).

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Harassment and its possible effects on bighorn sheep are discussed. Active harassment results in visible responses by sheep, while passive harassment produces no visible response but may have psychological and physiological effects on sheep. Harassment has significant impacts on individuals and populations, leading to a variety of conditions which reduce fitness. Minimizing harassment of sheep should be given top priority among management objectives (Boyle and Samson 1983).

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Management of U.S. National Parks is aimed at preserving park ecosystems in as pristine a condition as possible, and primarily involves preventing or compensating for human influences. So-called nonconsumptive uses such as sightseeing may in fact alter energy and geothermal pathways, disturbing park vegetation and wildlife. Managers must realize that these areas have a finite capacity for absorbing human disturbances (Boyle and Samson 1983).

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An overview of man's effect on game populations through land use and recreation is provided. Recreationists fleeing from polluted urban environments make demands on nature that must be harmonized with the capacity of the land to absorb them. Plans to control impacts of tourism must be worked out, especially in areas where it is no longer possible to reserve large areas of land for protection (Boyle and Samson 1983).

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Impacts of human-caused noise on wildlife and domesticated animals must be determined so that proper decisions can be made by policy makers. An animal-response model to quantify the effects of noise on animals is presented. Wildlife exposures to noise are generally involuntary and come from mobile sources such as airplanes and recreational vehicles (Boyle and Samsom 1983).

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Note: new.
Study area: Minnesota. Used traps. Meadow vole, short-tailed shrew, white-footed mouse, ground squirrel, masked shrew and spotted skunk. Study showed increased mortality of small mammals, destroyed subnivean air spaces. Also a possibility of toxic air trapped in snow. Even conservative levels of snowmobiling on trails is destructive to wintering small mammals.

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The author subjected waterbirds to experimental disturbance at the J. N. “Ding” Darling National Wildlife Refuge, located off the southern gulf coast of Florida, to investigate the effects of human actions on their behavior. Approaching the birds on foot was the most disruptive activities of refuge visitors. Photographers were most likely to engage in this activity. Visitors who spoke with refuge staff early during their visit caused the least disturbance. The author conclude that educational programs, coupled with the use of observation blinds or guided tours, could help reduce bird disturbance.
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The authors in this study evaluated the effects of human activity on the productivity of ospreys nesting in northwestern California during the early 1970s. The major form of intense human activity in the study is logging and the authors concluded that logging operations should be designed to minimize disruption of nesting ospreys, possibly by delaying operations in the area until young have fledged.

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323. Lieb, J. W. ACTIVITY, HEART RATE, AND ASSOCIATED ENERGY EXPENDITURE IN ELK OF WESTERN MONTANA. Ph.D. Thesis, Univ. of Montana, Missoula. 200 pp. 1981.
Note: new.

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Ecological analysis of a California sheep range revealed relationships between bighorn habitat use and human disturbance associated with a ski resort and a summer cabin. It was found that bighorn use did not occur where human use was heavy and sheep were forced into less satisfactory habitats (Boyle and Samson 1983).

325. Lime, D. W.; D. H. Anderson; and L. D. Mech. INTERPRETING WILDLIFE THROUGH GUIDED EXPEDITIONS. J. Interpret 3(2):10-16. 1978.
Guided expeditions were initiated in the Superior National Forest of Minnesota. People participating in wolf-howling safaris and wildlife-sign safaris had fun (in spite of only indirect encounters with wildlife) and at the same time learned about wildlife. This concept could be a useful method of public education about wildlife (Ream 1980).

326. Lindberg, K. and D. E. Hawkins, eds. ECOTOURISM: A GUIDE FOR PLANNERS AND MANAGERS. The Ecotourism Society. North Bennington, Vermont. 1993.
Note: new.

327. Lindenmayer, D. B. and H. A. Nix. ECOLOGICAL PRINCIPLES FOR THE DESIGN OF WILDLIFE CORRIDORS. Conservation Biology 7:627-630. 1973.
Note: new.

328. Lindzey, F. *MOUNTAIN LION. Pages 657-668 in: M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario. 1987.

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330. Lodico, N. J. ENVIRONMENTAL EFFECTS OF OFF-ROAD VEHICLES: A REVIEW OF THE LITERATURE. USDI Office of the Secretary, Washington, D.C. 1973.
Note: new.

331. Lodico, N. J. ENVIRONMENTAL EFFECTS OF VEHICLES: A REVIEW OF THE LITERATURE. USDI Research Services Branch, Bibliographic Service, Ofc. of Library Services, Bibliography Series No. 29. Washington, D.C. 109 pp. 1973.
Note: new.

332. Long, C. A. *MICROSOREX HOYI AND MICROSOREX THOMPSONI. Mammalian Species No. 33:1-4. 1974.

333. Lopez, B. H. *OF WOLVES AND MEN. Charles Schribner's Sons, New York. 304 pp. 1978.

334. Lyon, L. J. ROAD DENSITY MODELS DESCRIBING HABITAT EFFECTIVENESS FOR ELK. Journal of Forestry, September:592-595. 1983.
Note: new.
Forest roads evoke an avoidance response by elk.

335. MacAarthur, R. H. and E. O. Wilson. THEORY OF ISLAND BIOGEOGRAPHY. Princeton University Press, Princeton, N. J. 1967.
Note: new.

336. MacArthur, R. A.; R. H. Johnson; and V. Geist. FACTORS INFLUENCING HEART RATE IN FREE-RANGING BIGHORN SHEEP: A PHYSIOLOGICAL APPROACH TO THE STUDY OF WILDLIFE HARASSMENT. Can. J. Zool.; 57:2010-2021. 1979.
Heart rates of unrestrained female bighorn sheep were measured by telemetery in Alberta. In all ewes studied heart rate varied positively with activity level and inversely with distance from a road. Responses to other stimuli varied. Findings are discussed in relation to ecology and bioenergetics of bighorn sheep (Boyle and Samson 1983).

337. MacArthur, R. A.; V. Geist; and R. H. Johnson. CARDIAC AND BEHAVIORAL RESPONSES OF MOUNTAIN SHEEP TO HUMAN DISTURBANCE. J. Wildl. Manage.; 46:351-358. 1982.

338. MacNab, J. WILDLIFE MANAGEMENT AS SCIENTIFIC EXPERIMENTATION. Wildl. Soc. Bull. 11:397-401. 1983.
Note: new.

339. Maldague, M. IMPACT OF SNOWMOBILES ON THE FOREST ENVIRONMENT. Forest Conservation 39(9):6-8. 1973.
Note: new.

340. Manfredo, M. J., J. J. Vaske, and D. J. Decker. HUMAN DIMENSIONS OF WILDLIFE MANAGEMENT: BASIC CONCEPTS. In: Wildlife and Recreationists: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 17-31. Island Press, Washington, D.C. 1995.
Note: new.

341. Manfredo, M. J.; and R. A. Larson. MANAGING FOR WILDLIFE VIEWING RECREATION EXPERIENCES: AN APPLICATION IN COLORADO. Wildl. Soc. Bull.; 21:226-236. 1993.

342. Manning, R. E. IMPACTS OF RECREATION ON RIPARIAN SOILS AND VEGETATION. Water Resources Bulletin 50:30-43. 1979.
Note: new.

343. Manuwal, D. A. EFFECT OF MAN ON MARINE BIRDS: A REVIEW. In: Proc. Wildlife and People, C. M. Kirkpatrick, ed., pp. 140-160. Purdue Res. Foundation, West Lafayette, Ind. 1978.
Note: new.

344. March, D.; and C. Adams. A FRONT RANGE CONCEPT: THE NEED FOR THE NODDLES-RAMPART-SOUTH PLATTE RECREATION AREA. Wildlife-2000, Aurora, CO. 112 pp. plus appendices. 1973.
Results of a comprehensive study of wildlife, motorized recreation vehicles, and forest management in central Colorado are reported. Impacts of off-road vehicles on wildlife are severe, especially when engine noise is loud. Human recreational activities have accelerated habitat change which threaten vital watersheds and the wildlife which inhabit them (Boyle and Samson 1983).

345. Marshall, O. PRELIMINARY STUDIES ON THE EFFECTS OF SNOWMOBILE COMPACTION ON SOME TERRESTRIAL INVERTEBRATES. Amer. Zool. 1972.
Note: new.

346. Masyk, W. J. SNOWMOBILE, A RECREATION TECHNOLOGY IN BANFF NATIONAL PARK; ENVIRONMENTAL IMPACT AND DECISION-MAKING. Univ. of Calgary; The Univ. of Western Ontario, London, Ontario. 1973.
Note: new.

347. Mathisen, J. E. EFFECTS OF HUMAN DISTURBANCE ON NESTING BALD EAGLES. J. Wildl. Manage.; 32:1-6. 1968.
Bald eagle nesting success in Minnesota was studied in relation to intensity of several forms of human disturbance, including recreational activities. Human disturbance did not appear to significantly affect nest occupancy or nesting success (Boyle and Samson 1983).

348. Mayes, A. THE PHYSIOLOGY OF FEAR AND ANXIETY. In: Fear in Animals and Man, W. Sluckin, ed., pp. 24-55. Van Nostrand Reinhold Company, New York. 1979.
Note: new.
Physiological and behavioral responses to disturbance.

349. McClellan, B. N.; and D. M. Shackleton. IMMEDIATE REACTIONS OF GRIZZLY BEARS TO HUMAN ACTIVITIES. Wildl. Soc. Bull.; 17:269-274. 1989.
This study evaluated the responses of grizzly bears to human activities such as people on foot either next to or away from a parked vehicle, moving vehicles, heavy industrial equipment, fixed-wing aircraft, and helicopters. Bears responded more strongly to people on foot in remote areas than to any other stimuli. Management implications are discussed.

350. McCool, S. F. SNOWMOBILES, ANIMALS, AND MAN: INTERACTIONS AND MANAGEMENT ISSUES. Trans. North Amer. Wildl. and Nat. Resour. Conf. 43:140-148. 1978.
Note: new.

351. McCool, S. F. SNOWMOBILES, ANIMALS, AND MAN: INTERACTIONS AND MANAGEMENT ISSUES. The Wildlife Management Institute. Washington, D.C. 23 pp. 1978.
Note: new.

352. McCool, S. F. and B. Curtis. SOURCES OF CONFLICT AMONG WINTER RECREATIONISTS. In: Proc. North American Symposium on Dispersed Winter Recreation, pp. 73-77. Univ. of Minn. Office of Spec. Prog., Educ. Ser. 2-3. 1980.
Note: new.

353. McCord, C. M. and J. E. Cardoza. *BOBCAT AND LYNX. Pages 728-766 in: J. A. Chapman and G. A. Feldhamer, eds. Wild mammals in North America: biology, management, and economics. John Hopkins Univ. Press, Baltimore. 1982.

354. McGarigal, K.; R. G. Anthony and F. B. Issacs. INTERACTIONS OF HUMANS AND BALD EAGLES ON THE COLUMBIA RIVER ESTUARY. Wildlife Monograph; No. 15; 47p. 1991.
Note: Available at $4.50 from Wildl. Soc., 5410 Grosvenor Ln., Bethesda, MD 2014.

355. McIntyre, J. M. W. BIOLOGY AND BEHAVIOR OF THE COMMON LOON WITH REFERENCE TO ITS ADAPTABILITY IN A MAN-ALTERED ENVIRONMENT. Ph.D. Diss. Univ. of Minnesota, St. Paul. 243 pp. 1975.
Loons are subject to hazards from pollutants and increased recreational use because of their aquatic habits and conflict with man for habitat. Biological factors of loons were studied to assess their ability to adapt to these environmental changes. Their potential for maintaining stable populations in Minnesota are described based on the research results (Boyle and Samson 1983).

356. McMillan, J. F. SOME OBSERVATIONS ON MOOSE IN YELLOWSTONE NATIONAL PARK. Am. Midl. Nat.; 52(2):392-399. 1954.
In areas of heavy tourist pressure, moose develop considerable tolerance for human disturbance, moving slowly and returning soon. In a control area visitor disturbance caused moose to run from area and not return until at least the next day (Ream 1980).

357. McReynolds, H. E.; and R. E. Radtke. THE IMPACT OF MOTORIZED HUMANS ON THE WILDLIFE OF FORESTED LANDS. Pages 102-117 in: C. M. Kilpatrick. ed. Wildlife and people. Proc. of the 1978 John S. Wright Forestry Conf., 23-24 February 1978, Purdue Univ., West Lafayette, IN. 1978.
Effects of off-road vehicles on wildlife of forested lands are reviewed. Cases for and against the use of snowmobiles, motorcycles, and four-wheel drive vehicles in forests are presented. Few reliable data on off-road vehicle impacts on wildlife are available, but it is probable that indirect effects and unintentional harassment of wildlife have produced the greatest damage (Boyle and Samson 1983).

358. Meagher, M., S. Cain, T. Toman, J. Kropp, and D. Bosman. BISON IN THE GREATER YELLOWSTONE AREA: STATUS, DISTRIBUTION AND MANAGEMENT. Paper presented at the National Brucellosis Symposium, Jackson Hole, Wyo., September. 1994.
Note: new.

359. Meagher, M. THE BISON OF YELLOWSTONE NATIONAL PARK: PAST AND PRESENT. Ph.D. Dissertation, Univ. of Calif., Berkeley. 172 pp. 1970.
Note: new.

360. Meagher, M. *THE BISON OF YELLOWSTONE NATIONAL PARK. Natl. Park Serv. Sci. Monogr. 1:1-161. 1973.

361. Meagher, M. EVALUATION OF BOUNDARY CONTROL FOR BISON OF YELLOWSTONE NATIONAL PARK. Wildl. Soc. Bull.; 17:15-19. 1989.
Efforts made since 1976 to contain bison within the boundaries of Yellowstone National Park have proved to be ineffective. This paper evaluates several tactics to minimize the potential conflict of bison leaving the park. Hazing and herding activities demonstrated that bison can be moved only where they want to go. Attempts to block travel routes and harassment with various devices sometimes treated immediate problems at the locations involved, but did not change the overall direction of bison movement down the Yellowstone River. Further, these tactics apparently caused major shifts to other travel routes or sometimes displaced a conflict from 1 site to another. The author concludes that, in general, success (if any) in localized displacement of bison by human efforts will decrease and hazards to personnel will increase with these management approaches. Cropping of bison by public hunting outside the park will not change their movements, but may lessen local conflicts.

362. Meagher, M. RANGE EXPANSION BY BISON OF YELLOWSTONE NATIONAL PARK. Journal of Mammal. 70:670-675. 1989.
Note: new.
Bison use of plowed roads, an increase in numbers, acquired knowledge of new foraging areas, and the natural gregariousness of bison contributed to range expansion.

363. Meagher, M. WINTER WEATHER AS A POPULATION REGULATING INFLUENCE ON FREE-RANGING BISON IN YELLOWSTONE NATIONAL PARK. In: Research in Parks, Transactions of the National Park Centennial Symposium of the American Association for the Advancement of Science, Dec. 28-29, 1971. Ser. No. 1. Washington, D.C.: U.S. Government Printing Office. 232 pp. 1976.
Note: new.

364. Meagher, M. WINTER RECREATION-INDUCED CHANGES IN BISON NUMBERS AND DISTRIBUTION IN YELLOWSTONE NATIONAL PARK. Draft, report to management, unpublished. 48 pp. 1993.
Note: new.
Snow-packed roads used for winter recreation in the interior of the park appeared to be the major influence in major changes that occurred in bison numbers and distribution in Yellowstone, during the past decade. The entire bison population is involved, effects will ultimately occur on the ecosystem level. Range expansion, major shifts among subpopulations, mitigation of winterkill, and enhanced calf survival have resulted.

365. Meagher, M. WINTER RECREATION-INDUCED CHANGES IN BISON NUMBERS AND DISTRIBUTION IN YELLOWSTONE NATIONAL PARK. Unpublished. 1993.
Note: new.

366. Mech, L. D. *CANIS LUPUS. Mammalian Species No. 37. 6 pp. 1974.

367. Mech, L. D. *THE WOLF-THE ECOLOGY AND BEHAVIOR OF AN ENDANGERED SPECIES. Natural History Press, Doubleday, New York. 384 pp. 1970.

368. Mech, L. D. THE WOLVES OF ISLE ROYALE. Fauna of the National Parks of the U.S.; Fauna Series No. 7, U.S. Govt. Printing Office, Washington, D.C. 219 pp. 1966.
Gives occasional insights into the responses of wolves to the researcher on the ground, and to the aircraft used for observations. The researcher was not threatened by wolves, even when he examined recent kills. the wolves became habituated to the airplane used for observations and usually did not run even when repeatedly buzzed as low as 40 feet (Ream 1980).
369. Mech, L. D.; S. H. Fritts; G. L. Radde; and W. J. Paul. WOLF DISTRIBUTION AND ROAD DENSITY IN MINNESOTA. Wildl. Soc. Bull.; 16:85-87. 1988.
370. Mech, L. D.; T. J. Meier; and J. W. Burch. DENALI PARK WOLF STUDIES: IMPLICATIONS FOR YELLOWSTONE. Trans. N. Am. Wildl. Nat. Res. Resour. Conf.; 56:86-90. 1991.
371. Mech. L. D. WOLF POPULATION SURVIVAL IN AN AREA OF HIGH ROAD DENSITY. Am. Midl. Nat.; 121:387-389. 1989.
372. Melquist, W. E.; and M. G. Hornocker. *ECOLOGY OF RIVER OTTERS IN WEST CENTRAL IDAHO. Wildl. Monogr. No. 83:1-60. 1983.
373. Melquist, W. E.; and A. Dronkert. *RIVER OTTER. Pages 625-641 in: M. Novak; J. A. Baker; M. E. Obbard; and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources. Ontario. 1987.
374. Mietz, J. D. SNOWMOBILE IMPACT ON FOREST VEGETATION AT HEIBERG FOREST, NEW YORK. State University of New York, College of Environmental Science and Forestry, Syracuse. 1974.
Note: new.
375. Miller, S. G. and R. L. Knight. IMPACTS OF RECREATIONAL TRAILS ON AVIAN COMMUNITIES. In: Abstracts from the Society of Conservation Biology Meeting. Dept. of Fishery and Wildlife Biology, Colorado State University, Fort Collins. 1995.
Note: new.
376. Moen, A. N., S. Whittemore, and B. Buxton. EFFECTS OF DISTURBANCE BY SNOWMOBILES ON HEART RATE OF CAPTIVE WHITE-TAILED DEER (*Odocoileus virginianus*). New York Fish and Game Journal 29(2):176-183. 1982.
Note: new.
377. Moen, A. N. ENERGY CONSERVATION OF THE WHITE-TAILED DEER IN THE WINTER. Ecology; 57(1):102-198. 1976.
Analyzes energy-conserving behavioral adaptations of white-tailed deer in northwestern Minnesota during winter. Energy conservation of up to 1,000 Kcal/day for a 60 kg deer can result from reduced activity levels (seeking level land and lesser snow depth, walking slowly, etc.). Winter harassment by dogs or snowmobile traffic is detrimental to these adaptations (Ream 1980).

378. Moen, A. N. SEASONAL CHANGES IN HEART RATES, ACTIVITY METABOLISM, AND FORAGE INTAKE OF WHITE-TAILED DEER. J. Wildl. Manage.; 42(4):715-738. 1978.
White-tailed deer exhibited seasonal rhythms in heart rates, activities, and metabolism, with the lowest ecological metabolism occurring in the winter and highest in the summer. This rhythm is an adaptation for energy conservation; resource needs are lower when range resources are reduced. As metabolism rises in March and April, the intake of dormant forage should also rise until more digestible spring growth is available. The timing of the arrival of spring seems to be an important factor in population dynamics, with its effect being more pronounced 2 years later when the fawns should become members of the breeding population.

379. Montana Department of Fish, Wildlife and Parks. PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT. Montana Snowmobile Grant Program. Prepared by Statewide Trails Program Coordinator, Montana Dept. of Fish, Wildlife and Parks, 1420 E. Sixth Ave., Helena, Mont. 59620. 1993.
Note: new.

380. Montopoli, G. L. and D. A. Anderson. LOGISTICAL MODEL FOR THE CUMULATIVE EFFECTS OF HUMAN INTERVENTION ON BALD EAGLE HABITAT. Jour. Wildl. Manage. 55:290-293. 1991.
Note: new.

381. Morgantini, L. E.; and R. J. Hudson. HUMAN DISTURBANCE AND HABITAT SELECTION IN ELK. in: Symposium on Elk Ecology and Management, pp. 132-139; Laramie, WY. 1978 Apr 3.
Habitat selection by elk was not simply related to weather conditions or available food. Passive harassment resulting from human activities (vehicular and hunting) reduced elk use of open grassland (transected by roads) and caused overgrazing of marginal areas (away from roads). This may be especially hard on elk during severe winters when energy budgets are stressed (Ream 1980).

382. Morrison, J. R. EFFECTS OF SKI AREA EXPANSION ON ELK AND ACCURACY OF TWO TELEMETRY SYSTEMS IN MOUNTAINOUS TERRAIN. M. S. Thesis, Colorado State University, Fort Collins, Colo. 98 pp. 1992.
Note: new.

383. Murphy, J. R. NEST SITE SELECTION BY THE BALD EAGLE IN YELLOWSTONE NATIONAL PARK. Utah Acad. Sci. Arts Let. Proc. ; 42:261-264. 1965.
Along with proximity to water and food sources, human disturbance is suggested as an important factor determining bald eagle nest site selection in Yellowstone National Park. Instances of apparent disruption of bald eagle nesting by human intrusions are cited.

384. National Park Foundation. NATIONAL PARKS FOR THE 21st CENTURY-THE VAIL AGENDA. Report and recommendations to the Director of the National Park Service. Capital City Press, Montpelier, VT. 1992.

385. Neil, P. H.; R. W. Hoffman; and R. B. Gill. EFFECTS OF HARASSMENT ON WILD ANIMALS—AN ANNOTATED BIBLIOGRAPHY OF SELECTED REFERENCES. Colorado Division of Wildlife; Special Rep. No. 37, Denver. 21 pp. 1975.
Annotated Bibliography: This is a compilation of 68 annotated references dealing with the many forms of harassment of wild mammals and birds in their natural habitats. Emphasis in this bibliography is principally on the effects of off-the-road vehicles, free-roaming pets, urbanization and other habitat alterations, and hunting.

386. Nelson, M. E.; and L. D. Mech. RELATIONSHIP BETWEEN SNOW DEPTH AND GRAY WOLF PREDATION ON WHITE-TAILED DEER. J. Wildl. Manage.; 50(3):471-474. 1986.
Survival of 203 yearling and adult white-tailed deer was monitored for 23,441 deer days from January through April 1975-85 in northeastern Minnesota. Gray wolf predation was the primary mortality cause, and from year to year during this period, the mean predation rate ranged from 0.000 to 0.029. The sum of weekly snow depths/month explained 51% of the variation in annual wolf predation rate, with the highest predation during the deepest snow.

387. Nero, R. W. *THE GREAT GRAY OWL: PHANTOM OF THE NORTHERN FOREST. Smithsonian Institution Press,. 0167.

388. Neumann, P. W.; and H. G. Merriam. ECOLOGICAL EFFECTS OF SNOWMOBILES. Can. Field-Nat.; 86:207-212. 1972.
Studies in Ontario showed that snowmobiles caused significant changes in snow structure and wildlife behavior. Snowmobile use affected snowshoe hare and red fox mobility and distribution, and caused significant damage to browse plants (Boyle and Samson 1983).

389. Newby, F. E.; and P. L. Wright. *DISTRIBUTION AND STATUS OF THE WOLVERINE IN MONTANA. J. Mammal.; 36:248-253. 1955.

390. Newby, F. E.; and J. J. McDougal. *RANGE EXTENSIONS OF THE WOLVERINE IN MONTANA. J. Mammal.; 45:485-487. 1964.

391. Newton, I. *POPULATION ECOLOGY OF RAPTORS. Buteo Books, Vermillion, SD (397pp). 1979.

392. Norris, R. A. *COMPARATIVE BIOSYSTEMATICS AND LIFE HISTORY OF THE NUTHATCHES, SITTA PYGMAEA AND SITTA PUSILLA. Univ. Calif. Publ. Zool; 56:119-300. 1958.

393. Noss, R. F. and A. Y. Cooperrider. SAVING NATURE'S LEGACY: PROTECTING AND RESTORING BIODIVERSITY. Island Press, Washington, D.C. 1994.
Note: new.

394. Nyran, R. B.; and M. C. Jansson. PERCEPTION OF WILDLIFE HAZARD IN NATIONAL PARK USE. Trans. N. Am. Wildl. Nat. Resour. Cong.; 38:281-295. 1973.
Increased visitation to North American National Parks is resulting in more people-wildlife encounters, thus generating crucial management problems. Park management policies are subject to public opinions, which in turn depend on public perceptions. Results of a study to determine visitor perceptions of wildlife hazard in western National Parks are reported and management implications are discussed (Boyle and Sampson 1983).

395. Odum, E. P. TRENDS EXPECTED IN STRESSED ECOSYSTEMS. BioScience 35:419-422. 1985.
    Note: new.
396. O'Farrell, M. J. *STATUS REPORT: EUDERMA MACULATUM. Report to USDI, U.S. Fish Wildl. Serv., Albuquerque. 28 pp. 1981.
397. O'Farrell, M. J.; and E. H. Studier. *MYOTIS THYSANODES. Mammalian Species No. 137. 5 pp. 1980.
398. O'Farrell, M. J.; and E. H. Studier. *REPRODUCTION, GROWTH AND DEVELOPMENT IN MYOTIS THYSANODES AND M. LUCIFUGUS (CHIROPTERA: VESPERTILIONIDAE). Ecology; 54:18-30.
399. Olsen, D. L.; D. R. Blankenship; R. C. Erickson; R. Drewien; H. D. Irby; R. Lock; and L. S. Smith. WHOOPING CRANE RECOVERY PLAN. USDI, U.S. Fish and Wildlife Service; Washington, D.C. 206 pp.
    This recovery plan presents information on the history, biology, and status of the whooping crane, and detailed management plans aimed at restoring the whooping crane to nonendangered status. Among factors believed responsible for the near extinction of the species are various forms of indirect and direct human disturbance. Whoopers seem to tolerate some disturbance, but only for short periods of time and if no obvious threats occur (Boyle and Samson 1983).
400. Olson, S. T.; and W. Marshall. THE COMMON LOON IN MINNESOTA. Occasional Paper #5, Minnesota Mus. Nat. History, Univ. Minnesota Press, Minneapolis. 77 pp. 1952.
401. Olson, S. L.; and W. D. Edge. *NEST SITE SELECTION BY MOUNTAIN PLOVERS IN NORTHCENTRAL MONTANA. J. Range Manage.; 38:280-282. 1985.
402. Otvos, I. S. *ARTHROPOD FOOD OF SOME FOREST-INHABITING BIRDS. Can. Entomol.; 117:971-990. 1985.
403. Packard, J.; and L. D. Mech. *POPULATION REGULATION IN WOLVES. Pages 135-150 in: M. N. Cohen, R. S. Malpass, and H. G. Klein, eds. Biosocial mechanisms of population regulation. Yale University Press, New Haven. 406 pp. 1980.
404. Palmer, D. A. *HABITAT SELECTION, MOVEMENTS AND ACTIVITY OF BOREAL AND SAW-WHET OWLS. M.S. thesis; Colorado State Univ., Fort Collins. 101 pp. 1986.
405. Park, E. *THE WORLD OF THE OTTER. J. B. Lippencott, Philadelphia. 159 pp. 1971.
406. Parker, K. L.; C. T. Robbins; and T. A. Hanley. ENERGY EXPENDITURES FOR LOCOMOTION BY MULE DEER AND ELK. J. Wildl. Manage.; 48(2):474-488. 1984.
    Energy expenditures for several activities were measured using indirect calorimentry with 5 mule deer and 8 elk. The average energetic increment of standing over lying was 25%. Net energy costs (kcal/kg/km) of horizontal locomotion without snow decreased as a function of increasing body weight. The average cost per kilogram for each vertical meter climbed on a 14.3 degree incline was 5.9 kcal. Efficiency of upslope locomotion averaged 40-45% for the two species; downslope efficiency decreased with increasing body size. Energy expenditures for locomotion in snow increased curvilinearly as a function of snow depth and density. To further understand the energetics of locomotion in snow, foot loading and leg length were measured. Management implications, based on

the costs of locomotion for mule deer and elk when disturbed by winter recreationists and when traversing the slash deposition of logging operations are discussed.

407. Pederson, R. J. MANAGEMENT AND IMPACTS OF ROADS IN RELATION TO ELK POPULATIONS. In: Conf. Proc. Recreational Impact on Wildlands, R. Ittner, D. R. potter, J. K. Agee, and S. Anschell, eds., pp. 169-173. U.S. Forest Serv., U.S. Natl. Park Serv. R-6-001-1979. 1979.
Note: new.
Construction of roads in elk habitat effectively eliminated prime areas from elk production.

408. Pedevillano, C. and R. G. Wright. INFLUENCE OF VISITORS ON MOUNTAIN GOAT ACTIVITIES IN GLACIER NATIONAL PARK. Biological Conservation 39:1-11. 1987.
Note: new.
Goats at mineral licks apparently not disturbed by visitors, but goats attempting to cross goat underpasses were negatively affected by numbers of vehicles on the highway.

409. Peek, J. and D. B. Siniff. WILDLIFE-SNOWMOBILE INTERACTION PROJECT: PROGRESS REPORT. Univ. Minnesota Dept. Entom., Fish, Wildl., Ecol. and Behav. Biol., and Minn. Dept. of Natural Resources, St. Paul. 1972.
Note: new.

410. Pelton, M. R. *BLACK BEAR (URSUS AMERICANUS). Pages 504-514 in: J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America: biology, management, and economics. John Hopkins University Press, Baltimore. 1982.

411. Perkins, M. *THE PLIGHT OF PLECOTUS. Bats; 2:1-3. 1985.

412. Perry, C. and R. Overly. IMPACT OF ROADS ON BIG GAME DISTRIBUTION IN PORTIONS OF THE BLUE MOUNTAINS OF WASHINGTON, 1972-1973. Washington Game Department. 1976.
Note: new.
General reduction of use up to 1/8 mile from roads, depending on amount of roadside cover; deer substantially affected in meadows when cover was lacking.

413. Peters, R. P.; and L. D. Mech. *SCENT-MARKING IN WOLVES. American Scientist: 63:628-637. 1975.

414. Peterson, R. O. MANAGEMENT IMPLICATION OF WOLF-MOOSE RESEARCH, ISLE ROYALE NATIONAL PARK, MICH. Rept. to the Natl. Park Serv. 14 pp. 1977.
Wolves of Isle Royale tend to avoid contact with humans. Wolf use of park trails declines after visitors arrive in the spring. Selection of den and rendezvous sites indicates pronounces avoidance of humans. Management suggestions include limiting visitation, enlarging existing backcountry campsites rather than establishing new campgrounds, no further trail development, and discouragement of winter visitor use (Ream 1980).

415. Pomerantz, G. A.; D. J. Decker; G. R. Goff; and K. G. Purdy. ASSESSING IMPACT OF RECREATION ON WILDLIFE: A CLASSIFICATION SCHEME. Wildl. Soc. Bull.; 16:58-62. 1988.

416. Poole, A. THE EFFECTS OF HUMAN DISTRUBANCE ON OSPREY REPRODUCTIVE SUCCESS. Colon. Waterbirds; 4:20-27. 1981.
Effects of visits to osprey nests by researchers, trapping of breeding adults, and other human activities near nests were studied on the Atlantic coast from New York City to Boston, Massachusetts, and in Everglade National Park, Florida. No evidence was found of adverse effects of osprey reproduction from nest visits, although climbing nest trees may increase raccoon predation on young or eggs. Nests exposed to nearly continuos human activity produced young at rates equivalent to wilderness nests (Boyle and Samson 1983).

417. Potter, D. R.; K. M. Sharpe; and J. C. Hendee. HUMAN BEHAVIOR ASPECTS OF FISH AND WILDLIFE CONSERVATION: AN ANNOTATED BIBLIOGRAPHY. USDA, U.S. For. Ser. Gen. Tech. Rep. PNW-4. 288 pp. 1973.
Annotated Bibliography.

418. Powell, R. A. *THE FISHER-LIFE HISTORY, ECOLOGY AND BEHAVIOR. Univ. Minnesota Press, Minneapolis. 217 pp. 1982.

419. Progulske, D. R.; and T. S. Baskett. MOBILITY OF MISSOURI DEER AND THEIR HARASSMENT BY DOGS. J. Wildl. Manage.; 22(2):184-192. 1958.

420. Pruitt, W. O. SNOWMOBILES AND ALL-TERRAIN VEHICLES. Paper presented at Conference on Snowmobiles and All-Terrain Vehicles. Univ. of Western Ontario, Dept. Zool. Res. Report, University of Manitoba, Winnipeg, Canada. 1971.
Note: new.
Discussed impacts of snowmobiles on the subnivean environment.

421. Purdy, K. G., G. R. Goff, D. J. Decker, G. A. Pomerantz, and N. A. Connelly. GUIDE TO MANAGING HUMAN ACTIVITY ON NATIONAL WILDLIFE REFUGES. USDI Fish and Wildlife Service, Office of Information Transfer. Fort Collins, Colorado. 1987.
Note: new.

422. Purves, H. D.; C. A. White; and P. C. Paquet. WOLF AND GRIZZLY BEAR HABITAT USE AND DISPLACEMENT BY HUMAN USE IN BANFF, YOHO, AND KOOTENAY NATIONAL PARKS: A PRELIMINARY ANALYSIS. Heritage Resources Conservation, Canadian Parks Service, Banff, AB. 1992.
The SPANS Geographic Information System was used to analyze observations of radio collared wolves and grizzly bears. The value of existing habitat suitability models was tested for these two species, as well as the human displacement effect of varying intensities of human activity. Human activity levels were classified using an exponential scale of monthly traffic on human use vectors (roads and trails), or monthly person/days of use for human use points and polygons (campsites, towns, and ski areas).

Within Banff National Park (BNP) over 91% of the wolf telemetery observations occurred within ecosites rated as high and very high habitat capability. Most wolf observations were in the Bow Valley between Vermillion Lakes and Bow Lake and in the Spray Valley to Kananaskis Country. Wolves used the valley bottoms for travel corridors but showed aversion to regions where winter human use exceeded 10,000 visitors per month. The town of Banff has created a partial blockage to wolf movement denying wolves access to prime habitat east of the town.

Only 51% of the grizzly bear observations were in ecosites rated as high and very high capability within BNP, Yoho National Park (YNP), and Kootenay National Park (KNP). Of ten radio collared bears, four were habituated to humans, and therefore removed from future data analysis. Grizzly bear tolerance to human use was found to be within the range of 1,001-10,000 visitors per month. In the three parks, 335 square kilometers of available habitat were found to have use levels which exceeded the tolerance of non-habituated bears.

Given the displacement of wolves and grizzly bears by current human use levels in BNP, YNP, and KNP, and forecasted increases in visitation to these parks, management of human use is essential if humans, wolves, and grizzly bears are to continue to coexist. An objective of "no-net-loss" for carnivore habitat must be accepted by the Canadian Parks Service (CPS). A possible management strategy is to accommodate increased human activity in areas where wolves and grizzly bears have been totally displaced, and discourage increased human use of areas still used by these carnivores. In all cases, carnivore migration corridors must be preserved or widespread habitat alienation can occur.

As part of cumulative effects management, knowledge of displacement must be integrated with other factors that affect the survival of wolves and grizzly bears in the Canadian Rockies. It is recommended that a standing Environmental Assessment and Review Process (EARP) Panel should be established immediately to ensure that cumulative effects are recognized in preserving carnivores in YNP, KNP, and BNP.

423. Quinn, N. W. S.; and G. Parker. *LYNX. Pages 682-695 in: M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario. 1987.

424. Rabb, G. B. *REPRODUCTIVE AND VOCAL BEHAVIOR IN CAPTIVE PUMAS. J. Mammal.; 40:616-617. 1959.

425. Rapport, D. J., H. A. Regier, and T. C. Hutchinson. ECOSYSTEM BEHAVIOR UNDER STRESS. American Naturalist 125:617-640. 1985.
Note: new.

426. Ream, C. H. HUMAN-WILDLIFE CONFLICTS IN BACKCOUNTRY: POSSIBLE SOLUTIONS. Page 153-163 in: R. Ittner, D. R. Potter, J. K. Agee, and S. Anschell, eds. Recreational impacts on wildlands. Conf. Proc., 27-29 October 1978, Seattle, WA. U.S. For. Serv. R-6-001-1979. 1979.
Increasing backcountry recreational use and diminishing wildlands contribute to growing pressures on wildlife in backcountry areas. The extent of human impacts and possible solutions are reviewed. Deliberate harassment sometimes occurs, but the major impact of humans on wildlife results from unintentional disturbance. Management of people, wildlife, and habitat may be necessary to reduce human-wildlife conflicts (Boyle and Samson 1983).

427. Ream, C. H. IMPACT OF BACKCOUNTRY RECREATIONISTS ON WILDLIFE: AN ANNOTATED BIBLIOGRAPHY. USDA, U.S. For. Serv. Gen. Tech. Rep. INT-84. 1980.
*Annotated Bibliography.

428. Redmond, R. L.; and D. A. Jenni. *NATAL PHILOPATRY AND BREEDING AREA FIDELITY OF LONG-BILLED CURLEWS: PATTERNS AND EVOLUTIONARY CONSEQUENCES. Behavioral Ecology and Sociobiology; 10:277-279. 1982.

429. Redmond, R. L.; and D. A. Jenni. *POPULATION ECOLOGY OF LONG-BILLED CURLEWS IN WESTERN IDAHO. Auk; 103:755-767. 1986.

430. Regelin, W. L., C. C. Schwartz, and A. W. Franzmann. SEASONAL ENERGY METABOLISM IN MOOSE. J. Wildl. Manage. 49:388-393. 1985.
Note: new.

431. Reid, M.; R. Mule; and B. Renfrow. ASSESSMENT OF GRIZZLY BEAR UTILIZATION AND HABITAT QUALITY IN THE CLARK'S FORK SNOWMOBILE TRAIL CORRIDOR. Prep. for Douglas Hart B-4 Ranch. Prep. by KRA Nat. Resour. Consultants, Bozeman, MT. 54 pp. 1983.

432. Reid, N. J. PUBLIC VIEW OF WILDLIFE. Pages 77-80 in: Towards a new relationship of man and nature in temperate lands. Part 1: Ecological impact of recreation and tourism upon temperate environments. IUCN Tenth Technical Meeting, 26-30 June 1966, Lucerne, Switzerland, IUCN Publ. New Serv. 7, Morges, Switzerland. 1967.
Techniques for providing public viewing of wildlife in U.S. National Parks are discussed. Sound ecological management of parks resources can greatly improve wildlife viewing, and special viewing facilities and devices are suggested for increasing viewing opportunities. Park roads are often major viewing points in National Parks. Visitors should be encouraged to adjust their schedules to take advantage of seeing wildlife at their most active times (Boyle and Samson 1983).

433. Reinecke, K.; and D. Delnicki. DUCKDATA; A BIBLIOGRAHIC DATA BASE FOR NORTH AMERICAN WATERFOWL (ANATIDAE) AND THEIR WETLAND HABITATS. USDI, U.S. Fish Wildl. Ser. Res. Pub. 188. 1992.
*Annotated Bibliography (available from authors on formatted user-supplied diskettes in ProCite format, contains some 9,000 citations).

434. Renecker, L. A. and R. J. Hudson. SEASONAL ENERGY EXPENDITURES AND THERMOREGULATORY RESPONSES OF MOOSE. Can. Jour. Zoology 64:322-327. 1986.
Note: new.

435. Richens, V. B.; and G. R. Lavigne. RESPONSE OF WHITE-TAILED DEER TO SNOWMOBILES AND SNOWMOBILE TRAILS IN MAINE. Can. Field-Nat.; 92:334-344. 1978.
Studies of deer responses to snowmobiles in Maine revealed that deer were not driven from the area by snowmobiles and frequently followed snowmobile trails where the snow was firmer. It is suggested that snowmobiles could be used to manage deer in winter by providing trails where walking in snow is easier and inducing winter movements to suitable habitat (Boyle and Samson 1983).

436. Rocky Mountain/Southwestern Recovery Team. *AMERICAN PREGRINE FALCON RECOVERY PLAN (ROCKY MOUNTAIN, SOUTHWEST POPULATIONS). U.S. Fish Wildl., Denver, CO. 183 pp. 1977.

437. Roggenbuck, J. W. USE OF PERSUASION TO REDUCE RESOURCE IMPACTS AND VISITOR CONFLICTS. In: Influencing Human Behavior, M. J. Manfredo, ed., pp. 149-208. Sagamore Publishing, Inc. Champaign, Ill. 1992.
Note: new.

438. Rolley, R. E. *BOBCAT. Pages 670-681 in: M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario. 1987.

439. Rongstad, O. J. RESEARCH NEEDS ON ENVIRONMENTAL IMPACTS OF SNOWMOBILES. In: Off-road Vehicle Use: A Management Challenge, N. Andrews, L. Richard, and P. Nowak, eds., USDA Ofc. of Environmental Quality. Washington, D.C. 1980.
Note: new.

440. Rosenmann, M. and P. Morrison. PHYSIOLOGICAL CHARACTERISTICS OF THE ALARM REACTION IN THE DEER MOUSE. Physiological Zoologica 47:230-241. 1974.
Note: new.

441. Rost, G. A. and J. A. Bailey. DISTRIBUTION OF MULE DEER AND ELK IN RELATION TO ROADS. J. Wildl. Manage. 43:634-641. 1979.
Note: new.

442. Rost, G. R. RESPONSE OF DEER AND ELK TO ROADS. M.S. thesis; Colorado State University, Fort Collins. 51 pp. 1975.
Responses of deer and elk to roads on winter ranges in Colorado were studied by counting fecal pellet groups along transects perpendicular to roads. Deer and elk apparently avoided areas near roads, particularly areas within 200 meters of roads. Deer avoided even dirt roads, some of which were used only by four-wheel drive vehicles, trailbikes, and hikers (Boyle and Samson 1983).

443. Rost, G. R.; and J. A. Bailey. RESPONSES OF DEER AND ELK TO ROADS ON THE ROOSEVELT NATIONAL FOREST. Dept. Fish and Wildl. Biol., Colo. St. Univ., Ft. Collins. 19 pp. (mimeo). 1974.
In the mountain shrub and ponderosa pine vegetation zones on the Roosevelt National Forest, Colorado, deer and elk pellet-groups densities increased with distance from roads. Deer avoidance of roads was greater in the ponderosa pine zone. Paved, gravel and unimproved dirt roads were avoided. Limited data for elk indicated that elk avoid gravel roads but not dirt roads, which are usually snowbound when elk are present, in the ponderosa pine zone. It is not known if deer or elk will avoid roads to an extent that is detrimental to their welfare (Neil et al. 1975).

444. Ruggiero, L. F., G. D. Hayward, and J. R. Squires. VIABILITY ANALYSIS IN BIOLOGICAL EVALUATIONS: CONCEPTS OF POPULATION VIABILITY ANALYSIS, BIOLOGICAL POPULATION, AND ECOLOGICAL SCALE. Conservation Biology 8(2):364-372. 1994.
Note: new.
Reviewed population viability analysis (PVA). Suggested that assessments must address population persistence and habitat dynamics. A 7-step guide for PVA was provided.

445. Russell, D. OCCURRENCE AND HUMAN DISTURBANCE SENSITIVITY OF WINTERING BALD EAGLES ON THE SAUK AND SUIATTLE RIVERS, WASHINGTON. In: Proceedings of Washington Bald Eagle Symposium, R. L. Knight, G. T. Allen, M. V. Stalmaster, and C. W. Servheen, eds., pp. 165-174. 1980.
Note: new.

446. Sachet, G. A. INTEGRATED TRAIL PLANNING GUIDELINES FOR WILDLIFE, RECREATION AND FISH RESOURCES ON MT. HOOD NATIONAL FOREST. USDA Forest Service. 1990.
Note: new.

447. Saltz, D.; and G. C. White. URINARY CORTISOL AND UREA NITROGEN RESPONSES TO WINTER STRESS IN MULE DEER. J. Wildl. Manage.; 55(1):1-16. 1991.
The authors investigated the urinary cortisol and urea nitrogen responses of mule deer in winter population densities. Urine cortisol, assumed to reflect energy deficit, allows researchers to distinguish high levels of urea nitrogen caused by the availability of crude protein from those caused by muscle catabolism. The authors concluded that by reflecting both environmental and animal condition, urine cortisol provides a tool for assessing population condition and ecological density.

448. Salwasser, H. and F. Samson. CUMULATIVE EFFECTS ANALYSIS: AN ADVANCE IN FOREST PLANNING AND WILDLIFE MANAGEMENT. Tran. No. Amer. Wildl. and Nat. Res. Conf. 50:313-321. 1985.
Note: new.

449. Salwasser, H., C. Schoenwald-Cox, and R. Baker. ROLE OF INTERAGENCY COOPERATION IN MANAGING FOR VIABLE POPULATIONS. In: Viable Populations for Conservation, M. E. Soule, ed., pp. 159-173. Cambridge University Press. 1972.
Note: new.

450. Samuel, M. D. and R. E. Green. A REVISED TEST PROCEDURE FOR IDENTIFYING CORE AREAS WITHIN THE HOME RANGE. J. An. Ecology 57:1067-1068. 1988.
Note: new.
Revised his 1985 paper in same journal.

451. Schaller, G. B. *THE BREEDING BEHAVIOR OF THE WHITE PELICAN AT YELLOWSTONE LAKE, WYOMING. Condor; 66(1):3-23. 1964.

452. Schleyer, B. O. ACTIVITY PATTERNS OF GRIZZLY BEARS IN THE YELLOWSTONE ECOSYSTEM AND THEIR REPRODUCTIVE BEHAVIOR, PREDATION, AND USE OF CARRION. M. S. thesis, Montana State Univ., Bozeman. 1983.
Note: new.

453. Schmid, W. D. MODIFICATION OF THE SUBNIVEAN MICROCLIMATE BY SNOWMOBILES. In: Snow and Ice in Relation to Wildlife and Recreation, Symposium Proceedings, pp. 251-257. Coop. Wildl. Res. Unit, Iowa State Univ., Ames. 1971.
Note: new.

454. Schmid, W. D. SNOWMOBILE ACTIVITY, SUBNIVIAN MICROCLIMATE AND WINTER MORTALITY OF SMALL MAMMALS. Bull. Ecol. Soc. Am.; 53(2):37 (Abstract only).
Compaction of snowfields by snowmobiles alters the mild snow microclimate, potentially affecting organisms that live within or beneath the snow by increasing temperature stress or restricting movement. Experimental manipulation of a snowfield showed that winter mortality of small mammals was significantly increased by snowmobile compaction (Boyle and Samson 1983).

455. Schullery, P. *THE BEARS OF YELLOWSTONE. Yellowstone Library and Museum Assoc., Yellowstone National Park, WY. 176 pp. 1980.

456. Schultz, R. D. RESPONSES OF NATIONAL PARK ELK TO HUMAN ACTIVITY. M.S. thesis. Univ. of Montana. 95 pp. 1975.
Note: new.

457. Schultz, R. D.; and J. A. Bailey. RESPONSES OF NATIONAL PARK ELK TO HUMAN ACTIVITY. J. Wildl. Manage.; 42(1):91-100. 1978.
Responses of elk to human activities near a road were quantified for fall, winter, and spring in Rocky Mountain National Park. These elk, which experienced little or no hunting, were not significantly affected by normal on-road visitor activities (Ream 1980).

458. Scom, A. J., G. Bollinger, and O. J. Rongstad. STUDYING THE EFFECTS OF SNOWMOBILE NOISE ON WILDLIFE. Internoise Proceedings 236-241. 1972.
Note: new.

459. Scott, P.; and the Waterfowl Trust. *THE SWANS. Houghton Mifflin, Boston. 242 pp. 1972.

460. Seidensticker, J. C., IV; M. G. Hornocker; W. C. Wiles; and J. P. Messick. *MOUNTAIN LION SOCIAL ORGANIZATION IN THE IDAHO PRIMITIVE AREA. Wildl. Monogr. No. 35:1-60. 1973.

461. Serveen, C. W. ECOLOGY OF THE WINTERING BALD EAGLES ON THE SKAGIT RIVER, WASHINGTON. M.S. thesis; University of Washington, Seattle. 96 pp. 1975.
Bald eagle distributions in winter on the Skagit River, Washington, were related to habitat factors including human activity. Eagles initially utilized areas isolated from a road and receiving little human use, and only when food became less available in these areas were areas with more human activity utilized (Boyle and Samson 1983).

462. Several. SNOWMOBILES VERSUS WOLVES. International Wolf. 1992 Mar.
In response to the concern that snowmobile use may be harmful to wolf survival, the staff of "International Wolf" polled 40 wolf biologists with the question, "do you believe that snowmobiles are harmful to wolves in any way other than to provide accessibility to kill or harass them?" Excerpts from the seventeen biologists who responded are as follows:

Anonymous: "Snowmobile traffic may benefit wolves by packing the snow and allowing more efficient travel, particularly in deep snow. This probably allows more packs to travel their territories more rapidly, hunt more effectively, and advertise their territory (via scent marking and howling) more effectively. However, there must be some level of snowmobile traffic at which disturbance becomes detrimental. This may be 5 to 100 times the current level within wolf territories, but undoubtedly there exists some threshold at which the network of snowmobile trails and frequency of passage of snowmobiles would preclude wolf occupancy."

Berg, B., Wildlife Biologist, Department of Natural Resources, Minnesota: "Unless a snowmobiler is hell-bent on killing a wolf, snowmobiles traveling on established trails likely have little or no adverse impacts on wolves. Rather, snowmobiles trails may help both wolves and deer by providing ease of access to other habitats and food sources. Most snowmobile trails and secondary roads in Minnesota have wolf tracks on them, and many wolf pack territories in northern Minnesota contain or border on snowmobile trails.

With Minnesota's wolf population stable to slightly increasing, there is no reason to believe that average snowmobile traffic on established trails has any adverse effect."

Burch, J. Denali National Park, Alaska: "Wolves are smart, tough, adaptive animals both as individuals and as a species. There are several observations from both Alaska and Minnesota of wolves becoming accustomed to mechanized equipment. Wolves have proved their ability to deal with these disturbances and go on about their business as though they did not exist."

Darby, W. R. Ministry of Natural Resources, Ontario, Canada: "Snowmobile trails probably benefit wolves by making travel and access to prey easier."

Fuller, T. Asst. Prof., University of Massachusetts: "It seems clear that when no harassment is involved, and when the presence of vehicles does not otherwise disrupt normal behaviors, such vehicles likely are not harmful. However loud and unaesthetic snowmobiles may be to some people, wolves likely can adapt to them as long as there is no direct influence on behavior or survival."

Haber, G., Wildlife Scientist, Denali Park, Alaska: If there are wolves in the area, there could be unintentional harassment. If there is a snow machine buzzing around them, wolves are likely to exit that immediate area, at least temporarily, whether the driver is intentionally after them or not."

Herbert, D., Integrated Environmental Resource Manger, Alberta-Pacific Forest Industries, Inc., Canada: "Depending on the density of snowmobile activity and the size of the habitat area, I believe that most animals can accommodate this activity with short movements. Obviously, there is an activity level, even without harassment, that would limit accommodating movements".

"Although some evidence shows a change in [wolves] physiological response (heart rate), it has not been translated to increased mortality, body weight loss, etc. It is highly unlikely that this activity will affect wolf survival. It certainly won't in Canada. There is a possibility it might in Minnesota. However, if snowmobile activity reaches that level, it probably isn't safe for humans either."

Kunkel. K. E., Graduate Research Assistant, University of Montana: "As long as the miles of trails in a given area don't reach a density where security cover for wolves is greatly diminished, the impact should be minimal. What this trail density is, is probably unknown, but I can think of no trail system in the northeastern portion of Minnesota where it is excessive and can't imagine such a system developing and being consistently used."

Mech, L. D., Wolf Biologist, National Biological Survey, Minnesota: "In my experience, wolves readily adapt to traffic and noise of snowmobiles just as they do to those of vehicles. I know of many wolf pack territories through which snowmobiles pass regularly every winter and have never seen any evidence of harm to wolves from them."

Nelson. M., Wildlife Research Biologist, U.S. Fish and Wildlife Service, Minnesota: "Except for providing human accessibility to wolves, snowmobiles seem to present no direct threat to wolves. My observations of wolves in forested habitat indicate that wolves appear indifferent to snowmobile traffic that is not close to them (*i.e.,* farther away that 100-220 yards). This is the same apparent indifference wolves display toward vehicular traffic, heavy machinery and walking humans at similar distances."

Meier, T., Denali National Park, Alaska: I'm disturbed by the tendency to use wolves to promote other agendas. The result is usually a backlash against wolves and, more insidiously, a damage to the perception of wolves and natural systems in the minds of their strongest supporters. Wolves are not fragile losers who need our every effort to help them survive. They and their societies are robust and adaptable. If we refrain from killing them and allow them some prey to eat, they will thrive."

Peterson, R., Professor, School of Forestry and Wood Products, Michigan Technological University: "Wolves might avoid corridors used heavily by snowmobiles. One might expect this to be especially important where wolves are hunted/trapped. I am aware of no evidence that this is true, but such evidence is not easily obtained. Such avoidance, if it occurs, might not be important to a local wolf population, depending on distribution and abundance of prey. On the other hand, it is just as likely that wolves would utilize snowmobile trails for travel routes. Whether that might be beneficial or harmful to their long-term persistence is another open question."

Thiel, D., Coordinator, Sandhill Outdoor Skills Center, Department of Natural Resources, Wisconsin: "As our Cessna plane circled 300 feet above the snowy forest, I witnessed three members of the radioed Boot-jack pack nonchalantly devouring a deer, while within 300 feet, 15 snowmobilers passed by on an established trail. The "kill" was actually an unretrieved kill made two months earlier by a deer hunter, which the wolves had dug up and salvaged. Far from being intrusive, snowmobiles are simply a part of the wolves' winter environment and wolves deal with them as the circumstances dictate."

Wydeven, A., Wildlife Technician, Department of Natural Resources, Wisconsin: "In Wisconsin, we don't feel that normal traffic along designated trails probably has much effect on wolves. Travel off trails and near den sites in late winter may be more of a problem. Snowmobile traffic should probably be evaluated in relationship to road access concerns; where road densities (including snowmobile trails) become too high (one mile of road per square mile of land), the ability of wolves to exist will decline."

463. Severinghaus, C. W.; and B. F. Tullar. WINTERING DEER VERSUS SNOWMOBILES. Conservationist; 29(6):31. 1975.
Potential and observed effects of snowmobiles on wintering deer are discussed. Studies are cited in which deer were observed fleeing from approaching snowmobiles from as far as three quarters of a mile. Energy expenditure calculations demonstrate the danger of snowmobile harassment to deer already hard-pressed by winter conditions. Snowmobiles should not be permitted in deer wintering areas, and established trails should be kept at least one half mile from such areas (Boyle and Samson 1983).

464. Shaffer, M. L. MINIMUM VIABLE POPULATIONS COPING WITH UNCERTAINTY. In: Viable Populations for Conservation, M. E. Soule, ed., pp. 69-86. Cambridge University Press, Cambridge. 1987.
Note: new.

465. Shaffer, M. L. POPULATION VIABILITY ANALYSIS. Conservation Biology 4(1):39-40. 1990.
Note: new.

466. Shaffer, M. L. POPULATION VIABILITY ANALYSIS. In: Challenges in Conservation of Biological Resources: A Practioner’s Guide, D. Decker et al., eds., pp. 107-119. Westview Press, San Francisco, Calif. 1992.
Note: new.

467. Shea, D. S. A MANAGEMENT-ORIENTED STUDY OF BALD EAGLE CONCENTRATIONS IN GLACIER NATIONAL PARK. M.S. thesis; University of Montana, Missoula. 78 pp. 1973.
Observations of bald eagles congregating in Glacier National Park, Montana, revealed that the greatest threat to eagles in the park was disturbance caused by park visitors. Management recommendations include the protection of certain areas from visitor disturbance such as snowmobiling and boating, and the establishment of designated areas where viewing and photography can be managed (Boyle and Samson 1983).

468. Shea, R. E. ECOLOGY OF THE TRUMPETER SWAN IN YELLOWSTONE NATIONAL PARK AND VICINITY. M. S. thesis. Univ. of Montana. 132 pp. 1979.
Note: new.

469. Shoesmith, M. W. SEASONAL MOVEMENTS AND SOCIAL BEHAVIOR OF ELK ON MIRROR PLATEAU, YELLOWSTONE NATIONAL PARK. In: North American Elk: Ecology, Behavior and Management, M. S. Boyce and L. D. Hayden-Wing, eds., pp. 166-176. Univ. of Wyoming, Laramie. 1980.
Note: new.

470. Short, L. L. *HABITATS AND INTERACTIONS OF NORTH AMERICAN BLACK-BACKED WOODPECKERS. American Museum Novitates No. 2547:1-42. 1979.

471. Short, L. L. *HABITS AND INTERACTIONS OF NORTH AMERICAN THREE-TOED WOODPECKERS. American Museum Novitates No. 2547:1-42. 1979.

472. Short, L. L. *WOODPECKERS OF THE WORLD. Delaware Museum of Natural History, Greenville, DE. 676 pp. 1982.

473. Shult, M. J. AMERICAN BISON BEHAVIOR PATTERNS AT WIND CAVE NATIONAL PARK. Ph.D. Diss. Iowa State University, Ames. 191 pp. 1972.
Encounters with humans resulted in various responses by bison depending on the degree of harassment. Examples of possible effects of bison behavior on the American Indians of the Great Plains are presented (Boyle and Samson 1983).

474. Shultz, R. D.; and J. A. Bailey. RESPONSES OF NATIONAL PARK ELK TO HUMAN ACTIVITY. J. Wildl. Manage.; 42(1):91-100. 1978.
Responses of elk to human activities near a road were quantified for fall, winter and spring in Rocky Mountain National Park. These elk, which experienced little or no hunting, were not significantly disturbed by normal on-road visitor activities (Ream 1980),.

475. Sidhu, S. S.; and A. B. Case. A BIBLIOGRAPHY ON THE ENVIRONMENTAL IMPACT OF FOREST RESOURCE ROADS: A LIST. Newfoundland forest Research Centre, St. Johns, Info. Rep. N-X-149. 28 pp. 1977.
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476. Simberloff, D. and J. Cox. CONSEQUENCES AND COSTS OF CONSERVATION CORRIDORS. Conserv. Biol. 1:63-71. 1987.
Note: new.

477. Simberloff, D. and L. G. Abele. REFUGE DESIGN AND ISLAND BIOGEOGRAPHIC THEORY: EFFECTS OF FRAGMENTATION. Am. Nat. 120:41-50. 1987.
Note: new.

478. Singer, F. BEHAVIOR OF MOUNTAIN GOATS, ELK, AND OTHER WILDLIFE IN RELATION TO U.S. HIGHWAY 2, GLACIER NATIONAL PARK. Glacier National Park, West Glacier, MT. 96 pp. 1975.
Behavior, habitat use, and disturbance of elk, mountain goats, and other wildlife were studied in relation to a highway in Glacier National Park, Montana. Habituation to the highway made elk more vulnerable to poaching. Mountain goat-human interactions occurred frequently near a salt lick; goat reactions were avoidance of and/or flight from humans. Highway design and construction are discussed (Boyle and Samson 1983).

479. Singer, F. J. BEHAVIOR OF MOUNTAIN GOATS IN RELATION TO HIGHWAY 2, GLACIER NATIONAL PARK, MONTANA. J. Wildl. Manage.; 42(3):591-597. 1978.
A study was conducted in 1975 on mountain goats crossing a highway to visit a mineral lick in Glacier National Park, Montana. Collision hazards and high disturbance during crossings suggested that a goat crossing should be constructed and visitors should be restricted from the crossing area (Boyle and Samson 1983).

480. Singer, F. J. and J. B. Beattie. CONTROLLED TRAFFIC SYSTEM AND ASSOCIATED RESPONSES IN DENALI NATIONAL PARK. Arctic 39:195-203. 1986.
Note: new.
Moose were more alert to vehicle traffic than were caribou.

481. Singer, F. J. SOME PREDICTIONS CONCERNING A WOLF RECOVERY INTO YELLOWSTONE NATIONAL PARK: HOW WOLF RECOVERY MAY AFFECT PARK VISITORS, UNGULATES AND OTHER PREDATORS. Trans. N. Am. Wildl. Nat. Resour. Conf.; 57:567-583. 1991.

482. Skagen, S. K. BEHAVIORAL RESPONSES OF WINTERING BALD EAGLES TO HUMAN ACTIVITY ON THE SKAGIT RIVER, WASHINGTON. In: Proceedings of the Washington Bald Eagle Symposium, R. L. Knight et al., eds. The Nature Conservancy. 1980.
Note: new.
483. Skagen, S. K.; R. L. Knight; and G. H. Orians. HUMAN DISTURBANCE OF AN AVIAN SCAVENGING GUILD. Ecol. Appl.; 1:215-225. 1991.
484. Skiba, G. T. ECOLOGICAL EVALUATION OF THE DINOSAUR NATIONAL MONUMENT BIGHORN SHEEP HERD. M.S. thesis; Colorado State University, Fort Collins. 107 pp. 1981.
Human disturbance is one of several factors discussed relating to bighorn sheep ecology in Dinosaur National Monument, Colorado/Utah. An apparent sheep population decline has coincided with an increase in whitewater rafting through important sheep habitat, but observations suggest that sheep are not seriously disturbed by people on foot or in rafts. Management recommendations include considerations for location of campsites to minimize sheep disturbance (Boyle and Samson 1983).
485. Smith, A. T. and M. M. Peacock. CONSPECIFIC ATTRACTION AND THE DETERMINATION OF METAPOPULATION COLONIZATION RATES. Conservation Biology 4:320-323. 1990.
Note: new.
Recolonization of habitats after disturbance.
486. Snyder, H. A.; and N. F. R. Snyder. INCREASED MORTALITY OF COOPER'S HAWKS ACCUSTOMED TO MAN. Condor: 76:215-216. 1974.
Recovery patterns from 235 banded Cooper's hawk nestlings suggest that familiarity with man renders a hawk more likely to die from predation by man, especially shooting. Birds with frequent exposures to man from banding activities or observation from blinds were recovered more frequently after being killed by humans than birds with little exposure to man; such birds apparently have less fear of humans and are more vulnerable to human predation (Boyle and Samson 1983).
487. Soule, M. E. and D. Simberloff. WHAT DO GENETICS AND ECOLOGY TELL US ABOUT THE DESIGN OF NATURE RESERVES? Biol. Conservation 35:19-40. 1986.
Note: new.
488. Stace-Smith, R. MISUSE OF SNOWMOBILES AGAINST WILDLIFE IN CANADA. Nat. Can. 494):3-8. Ottawa. 1975.
Note: new.
489. Stalmaster, M. V. and J. A. Gessaman. ECOLOGICAL ENERGETICS AND FORAGING BEHAVIOR OF OVERWINTERING BALD EAGLES. Ecological Monographs 54:407-428. 1984.
Note: new.
High levels of human disturbance during winter could increase energy demands and result in increased mortality rates.
490. Stalmaster, M. V., J. K. Kaiser, and S. K. Skagen. EFFECTS OF RECREATIONAL ACTIVITY ON FEEDING BEHAVIOR OF WINTERING BALD EAGLES. J. Raptor Research 27(1):93. 1983.
Note: new.

491. Stalmaster, M. V.; and J. R. Newman. BEHAVIORAL RESPONSES OF WINTERING BALD EAGLES TO HUMAN ACTIVITY. J. Wildl. Manage.; 42(3):506-513. 1978.
Tolerance of wintering bald eagles in Washington to disturbance was determined by relating eagle distributions to human activity and measuring flight distances of eagles from simulated human disturbances. Human activity had adverse effects on eagle distribution and behavior. Management recommendations aimed at reducing human-caused disturbance are suggested (Boyle and Samson 1983).

492. Stalmaster, M. V.; and R. G. Plettner. DIETS AND FORAGING EFFECTIVENESS OF BALD EAGLES DURING EXTREME WINTER WEATHER IN NEBRASKA. J. Wildl. Manage.; 56(2):355-367. 1992.
The authors studied the diets and foraging efficiency of bald eagles on a system of reservoirs and canals adjacent to, and including a portion of, the Platte River System during extreme weather and extensive ice cover in southwestern Nebraska in 1989. Hunting, piracy, and scavenging comprised 87, 9, and 4% of 1,395 foraging attempts, respectively. Foraging opportunities and efficacy were enhanced by the maintenance of ice-free waters by hydroelectric and steam-plant operations, and by the disabling of prey by hydroelectric facilities. Adults were more effective foragers than subadults. The authors conclude that, with proper maintenance, power-generating facilities can benefit wintering eagles by providing foraging opportunities during periods of potential energy stress.

493. Stalmaster, M. V.; J. L. Kaiser and S. K. Skagen. EFFECTS OF RECREATIONAL ACTIVITY ON FEEDING BEHAVIOR OF WINTERING BALD EAGLES. J. Raptor Res.; 27(1):93. 1993.

494. Stankey, G. H., D. N. Cole, R. C. Lucas, M. E. Peterson, and S. S. Frissell. LIMITS OF ACCEPTABLE CHANGE (LAC) SYSTEM FOR WILDERNESS PLANNING. General Technical Report INT-176. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah. 1985.
Note: new.
Follows carrying capacity concepts (no set number of visitors). Sets quantifiable standards of impact levels that trigger management actions.

495. Stankey, G. H.; and D. W. Lime. RECREATIONAL CARRYING CAPACITY: AN ANNOTATED BIBLIOGRAPHY. USDA, U.S. For. Serv. Gen. Tech. Rep. INT-3. 45 pp. 1973.
*Annotated Bibliography.

496. Stemp, R. E. HEART RATE RESPONSES OF BIGHORN SHEEP TO ENVIRONMENTAL FACTORS AND HARASSMENT. M. S. Thesis, Univ. of Calgary, Alberta, Canada. 371 pp. 1983.
Note: new.

497. Stenzel. L. E.; H. R. Huber; and G. W. Page. *FEEDING BEHAVIOR AND DIET OF THE LONG-BILLED CURLEW AND WILLET. Wilson Bull.; 88:314-332. 1976.

498. Stephenson, R. O. CHARACTERISTICS OF WOLF DEN SITES. Alaska Dept. Fish Game Project W-017-R-06/WP14/J06/FIN. 29 pp. 1974.
Studies of wolf den site characteristics in the Brooks Range of Alaska and potential effects of human disturbance at den sites are discussed. Incidents of wolf-human interactions and factors important in determining wolf responses to humans are noted. It is suggested that in areas where wolves are shy of humans, prolonged human presence within 3.2 km of dens may affect wolf behavior and cause den abandonment (Boyle and Samson 1983).

499. Stevens, D. R. BIGHORN SHEEP MANAGEMENT IN ROCKY MOUNTAIN NATIONAL PARK. Proc. Bienn. Conf. North Am. Wild Sheep Goat Counc., 3. 1982.
One objective of bighorn sheep management in Rocky Mountain National Park, Colorado, has been to reduce the effects of park visitors on sheep. Visitor use of critical sheep habitats has been reduced by trail closures, and initial analysis indicates that disturbance of sheep has been reduced (Boyle and Samson 1983).

500. Stockwell, C. A., G. C. Bateman, and J. Berger. CONFLICTS IN NATIONAL PARKS: A CASE STUDY OF HELICOPTERS AND BIGHORN SHEEP TIME BUDGETS AT GRAND CANYON. Biological Conservation 56:317-328.
Note: new.
Frequent alerting affected food intake.

501. Storer, B. E. *ASPECTS OF THE BREEDING ECOLOGY OF THE PIGMY NUTHATCH AND THE FORAGING ECOLOGY OF WINTERING MIXED-SPECIES FLOCKS IN WESTERN MONTANA. M.S. thesis; Univ, Montana, Missoula. 1977.

502. Strickland, M. A.; C. A. Douglas; M. Novak; and N. P. Hunziger. *FISHER. Pages 586-598 in: J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America: biology, management, and economics. John Hopkins Univ., Baltimore. 1982.

503. Strickland, M. A.; C. W. Douglas; M. Novak; and N. P. Hunziger. *MARTEN (MARTES AMERICANA). Pages 599-612 in: Wild mammals of North America: biology, management, and economics. The John Hopkins Univ. Press, Baltimore. 1982.

504. Sweeney, J. M. and J. R. Sweeney. SNOW DEPTHS INFLUENCING WINTER MOVEMENTS OF ELK. Jour. of Mammalogy 65(3):524-526. 1984.
Note: new.

505. Swenson, J. E. ECOLOGY OF THE BALD EAGLE AND OSPREY IN YELLOWSTONE NATIONAL PARK. M.S. thesis; Montana State University, Bozeman. 146 pp. 1975.
Relationships of bald eagles and ospreys to human disturbances were examined during studies in Yellowstone National Park. Ospreys nesting on Yellowstone Lake had significantly lower nest success and productivity per occupied nest than ospreys nesting along streams, and the difference appeared to be related to human disturbance. Bald eagle reproduction did not appear to be affected by human disturbance. Management recommendations are presented (Boyle and Samson 1983).

506. Swenson, J. E. FACTORS AFFECTING STATUS AND REPRODUCTION OF OSPREYS IN YELLOWSTONE NATIONAL PARK. J. Wildl. Manage.; 43:595-601. 1979.
Reproduction of ospreys in Yellowstone National Park was higher along streams with little human disturbance than on Yellowstone Lake, where humans were more concentrated. Reproduction at active nests more than 1 km from a backcountry campsite on Yellowstone Lake was comparable to that for nests near streams. Since undisturbed ospreys reproduced at a rate allowing population stability, the elimination of disturbance by visitor management should allow the declining lake population to stabilize (Boyle and Samson 1983).
507. Swenson, J. E.; K. L. Alt; and R. L. Eng. *THE ECOLOGY OF THE BALD EAGLE IN THE GREATER YELLOWSTONE ECOSYSTEM. Wildl. Monogr. 95. 46 pp. 1986.
508. Taylor, C. R., N. C. Heglund, and G. M. Maloiy. ENERGETICS AND MECHANICS OF TERRESTRIAL LOCOMOTION. Jour. Exp. Biol. 97:1-21. 1982.
Note: new.
509. Telfer, E. S. and J. P. Kelsall. STUDIES OF MORPHOLOGICAL PARAMETERS AFFECTING UNGULATE LOCOMOTION IN SNOW. Can. Jour. Zool. 57:2153-2159. 1982.
Note: new.
510. Temple, S. A. *SYSTEMATICS AND EVOLUTION OF THE NORTH AMERICAN MERLINS. Auk; 89:325-338. 1972.
511. Tennessee State University, Memphis. EFFECTS OF NOISE ON WILDLIFE AND OTHER ANIMALS. U.S. Govt. Printing Ofc., Washington, D.C. 74 pp. 1971.
Note: new.
Prepared for U.S. Ofc. of Noise Abatement and Control.
512. Tenpas, G. H. EFFECTS OF SNOWMOBILE TRAFFIC ON NON-FOREST VEGETATION. Lake Superior Biological Conference, Ashland, Wisc. 1972.
Note: new.
513. Theil, R. P. RELATIONSHIP BETWEEN ROAD DENSITIES AND WOLF HABITAT SUITABILITY IN WISCONSIN. Am. Midl. Nat.; 113:404-407. 1985.
Data on demise of wolf and increase in road densities compared between 1926 and 1960. Wolves failed to survive when road densities exceeded 0.93 miles/sq. mi.
514. Thelander, C. G. SPECIAL WILDLIFE INVESTIGATIONS: BALD EAGLE REPRODUCTION IN CALIFORNIA, 1972-1973. Calif. Dept. Fish Game Project W-054-R-06/WP02/J05/8A. 18 pp. 1973.
Human disturbances interfere with nest selection and occupancy of bald eagles in California, posing a major threat to the already endangered population. A territory in a recreation area used by boaters, campers, and off-road vehicles was abandoned by eagles in 1972, possibly due to human disturbance (Boyle and Samson 1983).

515. Thomas, J. W., ed. WILDLIFE HABITATS IN MANAGED FORESTS IN THE BLUE MOUNTAINS OF OREGON AND WASHINGTON. USDA Forest Service Handbook 553. 512 pp. 1979.
Note: new.
A most comprehensive study of deer and elk management. Provides tools for identifying cover and vegetation types. Quantifies impacts from management activities, including roads.

516. Thompson, R. W. POPULATION DYNAMICS, HABITAT UTILIZATION, RECREATIONAL IMPACTS AND TRAPPING OF INTRODUCED ROCKY MOUNTAIN GOATS IN THE EAGLE'S NEST WILDERNESS AREA, COLORADO. Proc. Bienn. Symp. North. Wild Sheep Counc.; 2:459-464. 1980.
Recreation impacts on mountain goats was assessed by simulating disturbances and observing goat-human interactions in Colorado. Flight distance of goats was greatest for nanny and sub-adult groups, and averaged 82.6 m for all groups. The typical flight intensity was a slow walk away from the human. It is concluded that recreational impacts on the goat population are slight (Boyle and Sampson 1983).

517. Thorne, T.; G. Butler; T. Varcalli; K. Becker; and S. Hayden-Wing. THE STATUS, MORTALITY, AND RESPONSE TO MANAGEMENT OF THE BIGHORN SHEEP OF WHISKEY MOUNTAIN. Wyo. Game Fish Dept., Game Fish Res. Lab. Wildl. Tech. Rep. 7. 213 pp. 1979.
Ecological aspects of bighorn sheep studied in Wyoming included responses of sheep to encounters with humans. Sheep responses to humans varied with sex, age, and activity of sheep, environmental factors, and the nature of the disturbance. All mountain recreationists may stress sheep they encounter; stress induced by such passive harassment might be the most serious consequence of man-sheep encounters. Management recommendations include control of human-sheep interactions (Boyle and Samson 1983).

518. Thorne, E. T., R. E. Dean, and W. G. Hepworth. NUTRITION DURING GESTATIONN IN RELATION TO SUCCESSFUL REPRODUCTION IN ELK. J. Wildl. Manage. 40:330-335. 1976.
Note: new.

519. Thurber, J. M.; R. O. Peterson; T. D. Drummer; and S. A. Thomasma. GRAY WOLF RESPONSE TO REFUGE BOUNDARIES AND ROADS IN ALASKA. Wildl. Soc. Bull.; 22:61-68. 1994.
The response of gray wolves to different road types and human presence at the boundaries of Kenai National Wildlife Refuge, Alaska, was examined in a study of radio-collared wolves in 1976-1979. Wolf activity within discrete distances up to 5 km from roads and boundaries were computed. Wolves avoided oilfield access roads open to public use, yet they were attracted to a gated pipeline access road and secondary gravel roads with limited human use. Wolf response to a major public highway was equivocal, perhaps because wolves used a den only 1 km away. There was no detectable difference in wolf use of land on either side of the eastern refuge boundary adjacent to national forest lands, but on the western, settled boundary wolves used refuge lands more than adjacent private land. The data presented in this study suggests that wolf absence from settled areas and some roads was caused by behavioral avoidance rather than direct attrition resulting from killing of animals.

520. Tibbs, A. L. SUMMER BEHAVIOR OF WHITE-TAILED DEER AND THE EFFECTS OF WEATHER. M.S. thesis; Pennsylvania State University, State College. 93 pp. 1967.
During research of summer behavior of white-tailed deer in Pennsylvania, responses of deer to the presence of the observer and various other disturbances were noted. The observer on a 20-foot high observation tower did not appear to significantly affect deer behavior. Deer response to disturbance was inversely related to its regularity (Boyle and Samson 1983).

521. Titus, J. R.; and L. W. van Druff. RESPONSES OF THE COMMON LOON TO RECREATIONAL PRESSURE IN BOUNDARY WATER CANOE AREA, NORTHEASTERN MINNESOTA. Wildl. Monogr.; 79:3-59. 1981.
Results are reported of a field study to evaluate the impact of outdoor recreationists on nesting and breeding success of the common loon in Minnesota. The authors conclude that that human use of the Boundary Waters Canoe Area slightly reduces the nesting and breeding success of loons in high impact areas, but since some loons are undisturbed and others habituate to human use the adult breeding population has not declined in the past 25 years (Boyle and Samson 1983).

522. Toweill, D. E.; and J. E. Tabor. *THE NORTHERN RIVER OTTER (LUTRA CANADENSIS) (SCHREBER). Pages 688-703 in: J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America: biology, management, and economics. John Hopkins Univ. Press, Baltimore. 1982.

523. Tracy, D. M. REACTIONS OF WILDLIFE TO HUMAN ACTIVITY ALONG MOUNT McKINLEY NATIONAL PARK ROAD. M.S. thesis; University of Alaska, Fairbanks. 260 pp. 1977.
Reactions of 5 species of wildlife to human and vehicle activity on the park road in McKinley National Park were studied. Avoidance was observed for some bears, foxes, and possibly caribou; many other animals were attracted to the road. Of the ungulates studied, females with young were the most easily disturbed. Many animals appear habituated to human activities. Management recommendations based on the study are presented (Boyle and Samson 1983).

524. Trimble, S. A. *HABITAT MANAGMENT SERIES FOR UNIQUE OR ENDANGERED SPECIES-MERLIN. USDI, Bur. Land Manage. Tech. Note, Report No. 15, Denver. 41pp. 1975.

525. Tucker, P. ANNOTATED GRAY WOLF BIBLIOGRAPHY. USDI, U.S. Fish Wildl. Serv., Region 6, Denver, CO. 117 pp. 1988.
*Annotated Bibliography.

526. University of Wisconsin, Madison. EFFECTS OF SNOWMOBILE TRAFFIC ON NON-FOREST VEGETATION: SECOND REPORT. College of Agricultural and Life Sciences, Dept. of Agronomy, Univ. of Wisconsin, Madison. 1973.
Note: new.

527. U.S., Fish and Wildlife Service. *GRIZZLY BEAR RECOVERY PLAN. USDI, U.S. Fish Wildl. Ser., Washington, D.C. 199 pp. 1982.

528. U.S. Environmental Protection Agency. EFFECTS OF NOISE ON WILDLIFE AND OTHER ANIMALS. U.S. Environ. Prot. Agency, Off. Noise Abatement. Control NTID300.5. 74 pp. 1971.
Demonstrated and suspected effects of noise on wildlife and domestic animals are reviewed in this comprehensive report. Sources of noise potentially disturbing to wildlife include industries, automobiles, aircraft, and recreational vehicles (Boyle and Samson 1983).
529. U.S. Fish and Wildlife Service. *BALD EAGLE MANAGEMENT GUIDELINES OREGON-WASHINGTON. USDI; Fish and Wildlife Service, Portland Area Office, Oregon. 10pp. 1981.
530. U.S. Fish and Wildlife Service. *NORTHERN ROCKY MOUNTAIN WOLF RECOVERY PLAN. USDI, U.S. Fish Wildl. Ser., Denver. 119 pp. 1987.
531. U.S. Fish and Wildlife Service. *WHOOPING CRANE RECOVERY PLAN. U.S. Fish Wildl. Serv., Albuquerque. 283 pp. 1986.
532. USDI, U.S. Fish and Wildlife Service. GUIDELINES FOR THE MANAGEMENT OF THE AMERICAN WHITE PELICAN, WESTERN POPULATION. U.S. Fish Wildl. Ser. Unpub. ms. 44 pp. 1984.
533. USDI, U.S. National Park Service. PUBLIC USE AND RECREATION; VEHICLES AND TRAFFIC SAFETY. Federal Register 38. Feb. 14, 1973:4405-4407. 1973.
Note: new.
534. USDI, U.S. Fish and Wildlife Service. THE REINTRODUCTION OF GRAY WOLVES TO YELLOWSTONE NATIONAL PARK. U.S. Fish Wildl. Ser., Draft Environmental Impact Statement, Helena, MT. 1993.
535. USDI, U.S. National Park Service. STATEMENT FOR MANAGEMENT-GRAND TETON NATIONAL PARK. U.S. National Park Service. 1985.
536. USDI, U.S. Fish and Wildlife Service. *WHITE-FACED IBIS: MANAGEMENT GUIDELINES, GREAT BASIN POPULATION. U.S. Fish Wildl. Ser., Portland, OR. 31 pp. 1985.
537. USDI, U.S. National Park Service. WINTER USE PLAN ENVIRONMENTAL ASSESSMENT, YELLOWSTONE AND GRAND TETON NANTIONAL PARKS AND JOHN D. ROCKEFELLER, JR., MEMORIAL PARKWAY, WYOMING, IDAHO, AND MONTANA. 114 pp. 1990.
Note: new.
538. VanDyke, F. G., R. H. Brocke, H. G. Shaw, B. B. Ackerman, T. P. Hemker, and F. G. Lindzey. REACTIONS OF MOUNTAIN LIONS TO LOGGING AND HUMAN ACTIVITY. J. Wildl. Manage. 50:95-102. 1986.
Note: new.
539. Vaske, J. J., D. J. Decker, and M. J. Manfredo. HUMAN DIMENSIONS AND WILDLIFE MANAGEMENT: AN INTEGRATED FRAMEWORK FOR COEXISTENCE. In: Wildlife and Recreation: Coexistence Through Management and Research, R. L. Knight and K. J. Gutzwiller, eds., pp. 33-49. Island Press. Washington, D.C. 1995.
Note: new.

540. Vaske, J. J., A. R. Graefe, and F. R. Kuss. RECREATION IMPACTS: A SYNTHESIS OF ECOLOGICAL AND SOCIAL RESEARCH. Trans. North Amer. Wildl. and Nat. Resour. Conf. 48:96-107. 1983.
Note: new.

541. Vermeer, K. SOME ASPECTS OF THE NESTING REQUIREMENTS OF COMMON LOONS IN ALBERTA. Wilson Bull.; 85:429-435. 1973.
A significant correlation was found between number of breeding loons and the amount of human disturbance occurring at lakes. It is suggested that because loons appear to be intolerant of human disturbance they may serve as indicators of the wilderness qualities of lakes (Boyle and Samson 1983).

542. Wagar, J.V.K. RECREATION AND WILDLIFE PROBLEMS OF THE CENTRAL ROCKY MOUNTAINS. J. For.; 52:186-190. 1954.
Recreation based on wildlife resources in the central Rocky Mountains is discussed in terms of noneconomic value to participants. Problems such as value mesuration, financing of research, land ownership, and need for development are discussed (Boyle and Samson 1983).

543. Wall, G.; and C. Wright. THE ENVIRONMENTAL IMPACT OF OUTDOOR RECREATION. Univ. Waterloo, Ontarion, Dept. Geogr. Publ. Ser. 11. 69 pp. 1977.
A comprehensive review of environmental impacts of outdoor recreation is presented, including a chapter on wildlife impacts. Sections describe disturbance of wildlife, loss and gain of habitats, and changes in populations and species composition. The nature and scope of research on wildlife impacts are critically evaluated (Boyle and Samson 1983).

544. Wall, J. H. IMPACTS OF OUTDOOR RECREATION ON THE ENVIRONMENT. Council of Planning Librarians, Monticello, Ill., Exch. Bibliog. 1363. 19 pp. 1977.
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545. Wallace, G. N. VISITOR MANAGEMENT: LESSONS FROM GALAPAGOS NATIONAL PARK. In: Ecotourism: A Guide for Planners and Managers, K. Lindberg and D. E. Hawkins, eds., pp.55-81. The Ecotourism Society. North Bennington, Vermont. 1993.
Note: new.

546. Wallen, R. L. *ANNUAL BROOD SURVEY FOR HARLEQUIN DUCKS IN GRAND TETON NATIONAL PARK. Grand Teton National Park Resource Management files, Moose, WY. 15 pp. 1987.

547. Wallen, R. L. *HABITAT UTILIZATION OF HARLEQUIN DUCKS IN GRAND TETON NATIONAL PARK. M.S. thesis; Montana State University, Bozeman. 67 pp. 1987.

548. Wallen, R. L.; and C. R. Groves. *STATUS AND DISTRIBUTION OF HARLEQUIN DUCKS IN NORTHERN IDAHO. Unpublished Report, Idaho Dept. of Fish and Game, Boise. 34 pp. 1988.

549. Wallis, C. A.; and C. R. Wershler. *STATUS AND BREEDING OF MOUNTAINS PLOVERS IN CANADA. Can. Field-Nat.; 95:133-136. 1981.

550. Walter, H. and K. L. Garrett. EFFECTS OF HUMAN ACTIVITY ON WINTERING BALD EAGLES IN THE BIG BEAR VALLEY, CALIFORNIA. FINAL REPORT. USDA Forest Service, Big Bear District, Fawnskin, Calif. 79 pp. 1981.
Note: new.
Snow machines and ATVs are especially disturbing, probably due to association with random movement, loud noise, and operators are generally exposed.

551. Walter, H. IMPACT OF HUMAN ACTIVITY ON WILDLIFE. Pages 241-262 in: K. A. Hammond, C. Macinko, and W. B. Fairchild, eds. Sourcebook on the environment: A guide to the literature. University of Chicago Press, Chicago, Ill. 1978.
Literature concerning human impacts on wildlife is reviewed. Effects of human population expansion and utilization of energy and resources are emphasized, but nonconsumptive uses are also mentioned. Sections discuss general surveys, attitudes toward wildlife, changes in wildlife population levels, species diversity, and wildlife conservation, among others (Boyle and Samson 1983).

552. Wanek, W. J. and L. H. Schumacher. A CONTINUING STUDY OF THE ECOLOGICAL IMPACT OF SNOWMOBILING IN NORTHERN MINNESOTA. FINAL REPORT FOR 1974-1975. State College, Bemidji, Minn. 1975.
Note: new.

553. Wanek, W. J. ECOLOGICAL IMPACT ON VEGETATION AND SOIL MICROBES. In: Snowmobile and Off the Road Vehicle Research Symposium Proceedings. Recreation Resour., Michigan State Univ. 1973.
Note: new.

554. Wanek, W. J. SNOWMOBILING IMPACT ON VEGETATOIN, TEMPERATURES AND SOIL MICROBES. In: Snowmobile and Off the Road Vehicle Research Symposium Proceedings, pp. 117-130. 1971.
Note: new.

555. Ward, A. L. EFFECTS OF HIGHWAY CONSTRUCTION AND USE ON BIG GAME POPULATIONS. Fed. Highway Ofc. Res. and Dev. Rep. FHWA-RD-76-174. Nat. Tech. Inf. Serv., Springfield, Va. 92 pp. 1976.
Note: new.

556. Ward, A. L. TELEMETERED HEART RATE OF THREE ELK AS AFFECTED BY ACTIVITY AND HUMAN DISTURBANCES. In: Proceedings of Symposium: Dispersed Recreation and Natural Resource Management. Utah State Univ. 1977.
Note: new.
Two cow elk and a spike. Positive correlation to man-caused disturbance and elevated heart rates. Highest incidence occurred with loud noises and direct interaction.

557. Ward, A. L. and J. J. Cupal. TELEMETERED HEART RATE OF THREE ELK AS AFFECTED BY ACTIVITY AND HUMAN DISTURBANCE. Rocky Mt. Forest and Range Exper. Sta., Laramie, Wyo. 1980.
Note: new.

558. Ward, A. L.; J. J. Cupal; A. L. Lea; C. A. Oakley; and R. W. Weeks. ELK BEHAVIOR IN RELATION TO CATTLE GRAZING, FOREST RECREATION, AND TRAFFIC. Proc. N. Am. Wildl. Conf.; 38:327-337. 1973.
Telemetered elk in Wyoming study area preferred to be one-half mile distance from people who were camping, picnicking, and fishing. Suggests that in planning recreation facilities in elk habitat, people concentration areas should be one-half mile from elk feeding sites and provide adequate cover buffer zones (Ream 1980).
559. Warren, H. V. and R. E. Delavault, cited in H. L. Cannon and J. M. Bowles. CONTAMINATION OF VEGETATION BY TETRAETHYL LEAD. Science 137:765-766.
Note: new.
560. Watson, A. BIRD AND MAMMAL NUMBERS IN RELATION TO HUMAN IMPACT AT SKI LIFTS ON SCOTTISH HILLS. Jour. of Applied Ecology 16:753-754. 1979.
Note: new.
561. Weaver, J. L.; R. E. F. Escano; and D. S. Winn. A FRAMEWORK FOR ASSESSING CUMULATIVE EFFECTS ON GRIZZLY BEARS. Trans. N. Am. Wildl. and Nat. Resour. Conf.; 52:364-376. 1987.
562. Webb, R. H.; and H. G. Wilshire. AN ANNOTATED BIBLIOGRAPHY OF THE EFFECTS OF OFF-ROAD VEHICLES ON THE ENVIRONMENT. U.S. Geol. Surv. Open File Rep. 78-149. 15 pp. 1978.
Annotated Bibliography.
563. Weedin, R. NONCONSUMPTIVE USERS: A MYTH. Alaska Conserv. Rev.; 17(3):3,15. 1976.
Several examples of adverse impacts on wildlife from recreationists and scientists are cited to support the contention that nonconsumptive users of wildlife do not exist (Boyle and Samson 1983).
564. Werschkul, D. F.; E. McMahon; and M. Leitschuh. SOME EFFECTS OF HUMAN ACTIVITIES ON THE GREAT BLUE HERON IN OREGON. Wilson Bull.; 88:660-662. 1976.
565. Whelan, T. ed. NATURE TOURISM: MANAGING FOR THE ENVIRONMENT. Island Press, Washington, D.C. 1991.
Note: new.
566. White, P. S. and S. P. Bratton. AFTER PRESERVATION; PHILOSOPHICAL AND PRACTICAL PROBLEMS OF CHANGE. Biol. Conservation 18:241-255. 1980.
Note: new.
It is not only the recreationist who impacts wildlands, but the scientist, educator, and school group as well.
567. White, R. P. *DISTRIBUTION AND HABITAT PREFERENCE OF THE UPLAND SANDPIPER IN WISCONSIN. Amer. Birds; 37:16-22. 1983.
568. Whittaker, J. SNOWMOBILING OVER FORAGE GRASSES. Paper presented at Conference on Snowmobiles and All-terrain Vehicles at Univ. of Western Ontario, Canada. 1971.
Note: new.
569. Wiens, J. A. SPATIAL SCALING IN ECOLOGY. Functional Ecology 3:385-397. 1989.
Note: new.

570. Wilcox, B. A. and D. D. Murphy. CONSERVATION STRATEGY: THE EFFECTS OF FRAGMENTATION ON EXTINCTION. Am. Nat. 125:879-887.
Note: new.

571. Wilinson, T. GREATER YELLOWSTONE NATIONAL FORESTS. Falcon Press, Helena. 104 pp. 1991.

572. Wilkes, B. THE MYTH OF THE NONCONSUMPTIVE USER. Can. Field-Nat.; 91:343-349. 1977.
The concept that some outdoor recreational activities are nonconsumptive of the resource base is examined and rejected. Impacts of such on vegetation, wildlife, and the quality of the environment are noted. User restrictions, a proposed theory for non-use planning, and justification for landscape preservation are discussed (Boyle and Samson 1983).

573. Wilkinson. P. F. ENVIRONMENTAL IMPACT OF OUTDOOR RECREATION AND TOURISM: A BIBLIOGRAPHY. Vance Bibliographies, Monticello, Ill., Publ. Admin. Ser. Bibliogr. P-57. 90 pp. 1978.
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574. Williams, M. and A. Lester. ANNOTATED BIBLIOGRAPHY OF OHV AND OTHER RECREATIONAL IMPACTS TO WILDLIFE. Eldorado National Forest. USDA Forest Service, Pacific Southwest Region. 10 pp. 1996.
Note: new.

575. Wilmore, S. B. *SWANS OF THE WORLD. Taplinger Publ., New York. 229 pp. 1974.

576. Wilson, D. E. *WOLVERINE. Pages 644-652 in: J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America: biology, management, and economics. John Hopkins Univ. Press, Baltimore. 1982.

577. Wilson, L. O. THE FORGOTTEN DESERT BIGHORN HABITAT REQUIREMENT. Trans. Desert Bighorn Counc.; 13:108-113. 1969.
An important but often-neglected habitat requirement of bighorn sheep is space. A review of the literature shows that bighorn are generally intolerant of human disturbance. Management of developments, livestock grazing, other ungulates, and recreational activities should take into account adverse effects of these activities on bighorn sheep (Boyle and Samson 1983).

578. Witmer, G. W. and D. S. deCalesta. EFFECT OF FOREST ROADS ON HABITAT USED BY ROOSEVELT ELK. Northwest Science 59(2):122-124. 1985.
Note: new.
Six females monitored for one year. Human activity on forest roads alters distributions of elk habitat use. Impact may be mitigated by road closures, especially during rutting and calving seasons.

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Five mule deer does were caught by helicopter and net gun and were equipped with radio collars. They were habituated to an all-terrain Vehicle (ATV) travelling the same truck trail for 12 weeks. Three of the females were then followed by ATV for 9 minutes per day for 15 days between 1 to 24 October, 1981, for a total of 135 minutes. The harassed females, but not the other females, shifted feeding into darkness, used cover more frequently, left their home ranges more often, and increased flight distance from the ATV. In the following year the three harassed females collectively raised 1 fawn, having had normal reproduction the year before and the year after. Neither the unmarked females in the study area nor the two radio-collared control females suffered decreases in reproduction during the study. these results confirm expectations and are statistically significant.

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Appendix III

MATRIX OF WINTER RECREATION EFFECTS ON WILDLIFE

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March 1997

Index:

SNOWMOBILING

Bald Eagles

- "Since bald eagles apparently require freedom from human disturbance during the early stages of nesting. . . no habitat alterations, especially campgrounds, campsites or trails, should be made within 1 to 2km of a bald eagles nest" (Swensen 1975:121).

- in Grand Teton National Park, in reference to the RKO bald eagle nesting territory, "at the time of nest initiation there is still ample snow for snowmobiling on the plateau adjacent to the territory. This activity at or above the level of the nest could be inhibiting nest initiation or disrupting incubation during the early stages: (p. 64); recommended that a buffer zone of "1 km or any reasonable distance deemed necessary to minimize any possible disturbance by snowmobiles (p. 80); observed adults in close association with three territories along the Snake River on the earliest eagle observation flight (Feb. 26, 1979) (Harmata 1996).

- in Greater Yellowstone, bald eagles will persist only if there is "adequate habitat available to avoid humans" and management of wintering and migration habitat also should be considered (p. iv); "Eagles shifted their activity patterns to periods when their presence would be least obvious to humans: very early morning and evening" (p. 13); "Snowmachines and all terrain vehicles are especially disturbing, probably due to associated random movement, loud noise and operators are generally exposed . . ." (p. 12); The cumulative effects of many seemingly insignificant or sequential (human) activities may result in disruption of normal behavior of wildlife. "The importance and pertinence to bald eagle behavior cannot be overstated." (p. 14) (Harmata 1996).

- "Sensitivity of nesting bald eagles to human activity generally diminishes in the following temporal order: nest site selection>nest building>egg laying>incubation>brooding> fledging" (p. 37). This indicates that disturbance in winter may be influential nesting chronology, since nest site selection occurs "year round", nest building occurs "October through April" and egg-laying occurs "28 February through 10 April" (p. 37) in the Greater Yellowstone area (Harmata 1996).

- in Glacier National Park, the greatest threat to bald eagles was human disturbance; certain areas should be protected from snowmobiling (Shea 1975) (M.S. Thesis).

- in Grand Teton Park, snowmobiling could be inhibiting nest initiation or disrupting incubation at the RKO bald eagle nesting territory and a recommended buffer zone of "1km or any reasonable distance deemed necessary to minimize any possible disturbance by snowmobiles." During investigators first flight in 1979 on Feb. 26, adult eagles were observed in close association with 3 territories along the Snake River (Alt 1980:80) (M.S. Thesis).

—— human disturbance of an avian scavenger guild, includes bald eagles (Skagen et al. 1991).

—— in Yellowstone and Grand Teton Parks, bald eagles reside year-round. “Resident bald eagles begin defending territories in late January, display courtship in February, and begin laying eggs and incubating in March. They are sensitive to disturbance by humans from late winter through spring and early summer. Wintering bald eagles depend on three major types of food: waterfowl, carrion, and fish. . . .About 20-40 bald eagles, including 14 nesting pairs spend part of the winter in Yellowstone: (USDI National Park Service 1990:12).

Bears

—— a grizzly bear den was abandoned after snowmobile disturbance (Jonkel 1980).

—— in Yellowstone Park, black bears began denning between late October and mid-November. The winter dormancy period terminated primarily between late March and the end of April (Barnes and Bray 1967).

—— in Yellowstone Park’s Firehole, Madison and Gibbon River drainages, grizzly bears emerged from hibernation and traveled to elk and other native ungulate winter areas between March and early May (Cole 1972).

—— in Grand Teton and Yellowstone Parks, “Bears usually emerge from dens in mid-March, but they may emerge earlier depending on elevation, slope, aspect, weather conditions, and the individual bear’s age, sex, condition and behavioral patterns. . .The late winter to early spring period is a crucial feeding time. . .winter-killed carrion. . .is an important source of protein. . .bears. . .must feed undisturbed in preferred areas to meet nutritional requirements. . .Adult females and young grizzlies, especially, need carrion and suffer most from its exclusion for their diet. . .When adult females are excluded on a regular basis from carrion sources, higher mortality and lower fecundity rates can be expected” (USDI National Park Service 1990:15).

Bighorn Sheep

—— on winter range, may be debilitating to winter-stressed sheep (Berwick 1968) (M.S. Thesis).

—— heart rates of unrestrained bighorn sheep varied inversely with distance from a road, in Alberta (MacArthur et al. 1979).

—— cardiac and behavioral responses of bighorn sheep to human disturbance (MacArthur et al. 1982).

Bison

— in Yellowstone Park, snow packed roads used for winter recreation in the interior of the park appeared to be the major influence in major changes in bison numbers and distribution in the park, in the past decade. Roads provided energy-efficient travel that resulted in energy saving within traditional foraging areas, range expansion, major shifts among previously semi-isolated subpopulations, and a mitigation of winterkill and enhancement of calf survival. Effects will ultimately occur on an ecosystem level (Meagher 1993).

— in Yellowstone Park, "Bison were frequently observed traveling in the packed and groomed snowmobile trail and habitually used the trail as part of their intricate network of trails during the winter months" (Aune 1981:34).

Elk

— in Yellowstone Park, resulted in average flight distance of 33.8 m (Aune 1981) (M.S. Thesis).

— in Montana, additional stress from snowmobiles in winter is undesirable (Aasheim 1980).

— in Idaho, road closures allowed elk to remain longer in preferred areas (Irwin and Peek 1979).

— forest roads evoke an avoidance response by elk (Lyon 1983).

— in Rocky Mountain Park, quantified responses of elk to human activities, in winter; non-hunted elk were not significantly affected by on-road visitor activities (Schultz and Bailey 1978).

Mule Deer

— after habituating to an all-terrain vehicle (ATV) for 12 weeks, harassment of radio-collared females by the ATV altered feeding, altered spatial use, and decreased production of young the following year (Yarmaloy 1988).

— elicited motor responses (in sagebrush winter range) when closer than 133m; moved at similar velocities when disturbed by snowmobiles or persons afoot; moved shorter horizontal distance when disturbed by snowmobiles than when disturbed by persons afoot; became <u>more</u> sensitive in moving away from disturbances, as the controlled trials progressed. Test disturbances did not prevent adult females from producing fawns later that year. (See Freddy et al. 1966 in "SNOWSHOEING" section.) (Used 18 radio-collared adult females, Colorado.) (Freddy et al. 1966).

— in Yellowstone Park, resulted in average flight distance of 28.6m (Aune 1981).

— recommended that snowmobiles remain more than 470m from mule deer, in winter, in Colorado (Freddy et al. 1986).

White-tailed Deer

— altered spatial rise, Minnesota (Dorrance 1975).

— increased home-range sizes, Minnesota (Dorrance 1975).

— displaced animals from the vicinity of snowmobile trails, Minnesota (Dorrance 1975).

— routing snowmobile trails away from deer concentration areas was suggested (Eckstein et al. 1979).

— appeared to force deer into less-preferred habitats where nighttime radiant heat loss was increased, Wisconsin (Huff and Savage 1972).

— reduced home-range sizes, Wisconsin (Huff and Savage 1972).

— was detrimental to energy-conserving behavioral adaptations for winter survival, Minnesota (Moen 1978).

— provided trails that deer used, probably reducing energy expenditures, Maine (Richens and Lavigne 1978).

— caused energy expenditures to deer in wintering areas, expenditures calculated, New York (Severinghaus and Tullar 1975).

— effects on distribution in south-central Minnesota (Kopischke 1972).

— snowmobile trails enhanced deer mobility and probably reduced deer energy expenditures; snowmobile disturbance did not cause abandonment of preferred bedding and feeding sites, caused deer responses varying from running out of sight to remaining in place (Lavigne 1976) (M.S. Thesis).

— in responses to snowmobile activity, were more pronounced in a hunted than in an unhunted population of deer (Dorrance et al. 1975).

— established snowmobile trails should be kept at least one-half mile from white-tailed deer wintering areas, in New York (Severinghaus and Tullar 1975).

Trumpeter Swans

— in Yellowstone Park "No future activities should be planned which would increase human use of the north shore of Yellowstone Lake and the Yellowstone River from Fishing Bridge to Alum Creek after 20 October." At the time of her study, up to 100 trumpeters wintered in Yellowstone, although numbers were usually much lower (p. 109); "Land management agencies should direct human activities away from wintering and nesting sites. . .Winter activities such as snowmobiling or cross-country skiing will cause most swans to fly if the person can be seen. Snowmobile and ski trails should be routed away from the river courses" (Shea 1979:111) (M.S. Thesis).

Subnivian Mammals/Small Mammals

— increased mortality in small mammals beneath snow-packed trails; snow compaction by snowmobiles resulted in destruction of air spaces, reduced snow depth, increased snow density and increased thermal conductivity. Also a possibility of toxic air trapped in snow (4% carbon dioxide); destruction of wintering of small mammals at even conservative levels of snowmobile use (mammals trapped in the study: meadow vole, short-tailed shrew, white-footed mouse, ground squirrel and spotted skunk), Minnesota (Jarvinen and Schmid 1971).

— discusses possible effects on small mammals (Aasheim 1980).

— snowmobile compaction of snow changes the physical and thermal properties and potentially affects animals that live beneath the snow in winter (Corbet 1970).

— effects on small mammals (Bury 1978).

— in Minnesota, studied snowmobile use and winter mortality; used traps; meadow vole, short-tailed shrew, white-footed mouse, ground squirrel, masked shrew, spotted skunk, showed increased mortality of small mammals; destroyed subnivian air space, possibly trapped toxic air in snow. Even conservative levels of snowmobiling on trails is destructive to wintering small mammals (Jarvinen and Schmidt 1971; Schmidt 19971, Schmidt 1972).

— snowmobile use affected snowshoe hare and red fox mobility and distribution, in Ontario, mainly within 76 meters of snowmobile trail; hares avoid snowmobile trails, foxes use them (Neumann and Merriam 1973).

— discussed impacts of snowmobiles on the subnivian environment (Pruitt 1971).

Terrestrial Invertebrates

— preliminary studies of snowmobile compaction on invertebrates (Marshall 1972).

Fish

—— ability to swim diminished by snowmobile exhaust (lab and field studies on fingerling brook trout) (Adams 1975).

—— Baldwin, M.F. 1968

—— Bury, R.C. 1978.

—— polluted snow effects on freshwater and aquatic organisms (Hagen and Langeland 1973).

—— effects of snowmobiles on fish resources (Doan 1970).

—— "fish stop swimming in response to ground or sound vibrations" (Gabrielson and Smith 1995:100).

—— detection and reaction of fish to infrasound (Enger et al. 1993).

General

—— a literature review of wildlife harassment by snowmobiles. Documents Congressional testimony on impacts of snowmobiles on wildlife and recommends the prohibition of snowmobiles in national parks (Baldwin and Stoddard 1973).

—— in Ontario, snowmobiles caused significant changes in wildlife behavior; snowshoe hares and red foxes were disturbed mainly within 76 meters of the snowmobile trail; hares avoided snowmobiles trails, foxes used them (Neumann and Merriam 1972).

—— motorized recreational activities are generally much more destructive than nonmotorized activities (p. 194); "the indirect impacts of recreation on wildlife are clearly substantial but even more poorly understood than the direct impacts: (p. 196) (Cole and Landres 1995).

—— lead contamination associated with snowmobile trails (Collins and Snell 1982).

—— contamination of vegetation by tetraethyl lead (Cammon and Bowles 1962).

—— cites snowmobile harassment of ungulates (Curtis 1974).

—— effects on large mammals, medium-sized mammals, small mammals (Bury 1978).

—— effects on fish and wildlife resources (Doan 1970).

— "When people intrude into wildlife habitat, stress on wildlife populations is one result. Snowmobile activity is a particular problem as people move into wintering areas where animals may already be stressed" (Anderson 1995:163).

SNOWSHOEING/HIKING

Bears

— grizzlies do not actively defend dens from humans (Craighead and Craighead 1972).

Bighorn Sheep

— in California, protection of bighorn sheep includes regulation of hiking and sightseeing (DeMarchi 1975).

— in California, hikers did not appear to be adversely affecting sheep on Mount Baxter; if numbers of hikers increase, effects should be monitored (Elder 1977).

— minimizing harassment of sheep should be given top priority among management objectives (Horejisi 1976).

— in Rocky Mountain Park, visitor use of critical bighorn sheep habitats has been reduced by trail closures (Stevens 1982).

— impacts of hiking on Desert Bighorns (Graham 1980).

— in Colorado, hiking influences bighorn sheep distributions and activities (Bear and Jones 1973).

Birds

— see entry for Bald Eagles (Stalmaster and Newman 1978) of this report in section "Stress Induced by Human Activity. . ."

— how close certain passerine bird species will tolerate an approaching human (Cooke 1980).

— in Colorado, in winter, measured flushing responses and distances of American kestrels, merlins, prairie falcons, rough-legged hawks, ferruginous hawks, and golden eagles, when disturbed by humans walking or by vehicles. Walking disturbances resulted in more flushes than vehicle disturbances for all but prairie falcons (Holmes et al. 1983).

Elk

- in Rocky Mountain Park, elk made greater use of areas near roads as the winter-spring study progressed. People approaching animals off-roads usually caused elk to leave open areas; elk exhibited longer flight distances from an approaching person than from an approaching vehicle (Schultz and Bailey 1978).

- in Rocky Mountain Park, snowshoers and hikers occasionally disturbed elk along trails; did not quantify elk reactions; larger herds had greater flight distances (p.36); deep snow, blowing snow, and falling snow were frequently associated with shorter flight distances (p. 45) (Schultz 1975) (M.S. Thesis).

- on Colorado winter ranges, deer and elk avoided areas near roads, particularly areas within 200 meters of roads; deer avoided even dirt roads, some of which were used by hikers (Rost 1975) (M.S. Thesis).

Moose

- in Wyoming, moose were tolerant of close observers when no quick motions or loud noises were made (Denniston 1956).

- in Wyoming, moose moved away when approached on foot within 20-60 feet (Altman 1958).

- in Yellowstone, moose develop considerable tolerance for human disturbance in areas of heavy tourist pressure, but in a control area visitor disturbance caused moose to run and not return to the area until at least the next day (McMillan 1954).

- responses of moose to presence of humans (Corbus 1972).

Mule Deer

- in Colorado, deer were interrupted for longer durations by persons afoot than by snowmobiles; recommended that persons afoot remain more than 334m from mule deer, in winter (Freddy et al. 1986).

SKIING

Bighorn Sheep

- impacts of ski lifts on Desert Bighorns (Graham 1980).

—— in California, human disturbance associated with a ski resort; where human use was heavy, Desert Bighorns were forced into poorer habitats (Light 1983).

Elk

—— in Yellowstone Park, resulted in average flight distance of 53.5m (Aune 1981) (M.S. Thesis).

—— in Yellowstone Park, the median distance at which elk started to move when skiers approached was 400m at Lamar and Stephen's Creek and 15m at Mammoth. Median flight distances moved from disturbance were 42 times greater at Lamar and Stephen's Creek than at Mammoth. No evidence of elk habituation or avoidance was associated with repeated disturbances during the study. At Lamar and Stephen's Creek, elk were displaced from the drainage for at least the duration of human presence and on average returned within 2 days in the absence of human activity. In 5 (of 40) instances, marked elk did not return to the drainages they left when disturbed. Median energy expenditure for movement was 335 Kcal/disturbance (Cassirer et al. 1992) (M.S. Thesis).

—— in Elk Island National Park, Alberta, influence of nordic skiers on elk distribution (Ferguson and Keith 1982).

—— effects of ski area expansion on elk in mountainous terrain (Morrison 1992) (M.S. Thesis).

Moose

—— in Elk Island Park, Alberta, the influence of nordic skiing on moose distribution (Ferguson and Keith 1982).

Mule Deer

—— in Yellowstone Park, resulted in average flight distance of 52.4m (Aune 1981) (M.S. Thesis).

Trumpeter Swans

—— in Yellowstone Park, "No future activities should be planned which would increase human use of the north shore of Yellowstone Lake and the Yellowstone River from Fishing Bridge to Alum Creek after October 20. Land management agencies should direct human activities away from wintering and nesting sites. . .Winter activities such as snowmobiling or cross-country skiing will cause most swans to fly if the person can be seen. Snowmobile and ski trails should be routed away from river courses" (Shea 1979) (M.S. Thesis).

Wolves and Grizzly Bears

—— used GIS to analyze observations of radio-collared wolves and grizzly bears in respect to human activity levels on roads, trails and at ski areas (Purves et al. 1992).

—— in Banff, Yoho, and Kootenai Parks, Canada, where winter human use exceeded 10,000 visitors per month, wolves showed aversion to such areas (Purves et al. 1992).

General

—— effects of skiing on wildlife in Michigan (Young and Boyce 1971).

ENERGY EXPENDITURES BY WILDLIFE FOR LOCOMOTION

Bighorn Sheep

—— prediction of energy expenditures by Rocky Mountain bighorns (Chappel and Hudson 1980).

—— energy expenditures resulting from harassment were most damaging when sheep were in poor condition (Geist 1971).

Elk

—— in Montana, free-ranging elk herds are generally restricted by snow depths exceeding 46cm (Beall 1974) (Ph.D. Thesis).

—— in Montana, activity, heart-rate and associated energy expenditures (Leib 1981) (Ph.D. Thesis).

—— energy expenditures for several activities were measured using indirect calorimetry with 5 mule deer and 8 elk; energy expenditures for locomotion in snow increased curvilinearly as a function of snow depth and density. “The additional energy drain on a wintering population on poor range may be an important factor in survival” (Parker et al. 1984:486).

Mule Deer

—— see entry for Parker et al. 1984 under “ELK,” above.

—— in Colorado, when forced from lying to running by persons afoot, increased energy expended from 9 Kcal to 54-127 Kcal; for snowmobiles, this increase was from 2 to 10-25 Kcal (Freddy et al. 1966).

White-tailed Deer

- in New York, snowmobile trails should be kept at least one-half mile from deer concentrations in winter; used energy expenditure calculations to demonstrate danger of snowmobile harassment to winter-stressed deer (Severinghaus and Tullar 1975).

- analysis of deer responses to environmental changes should be on a sequential basis rather than as an overall average; a deer does not respond the same to equally cold weather conditions in November and March. In March, the fat reserve is depleted, females may be carrying fetuses, and requirements for gestation are increasing rapidly (Moen 1976).

- in Maine, deer frequently followed snowmobile trials (Richens and Lavigne 1978).

General

- "While all impacts on animals cannot be documented, it is clear that loss of body reserves has negative effects on the individuals concerned. When combined with other factors such as stressful winters, the animals could die or fail to reproduce. In such cases, populations would decline. When a disturbance occurs over a large region for many years, the population may be unable to continue to reproduce and survive in the area" (Anderson 1995:164).

- running increased the need of ruminants for food (Geist 1971).

- morphological parameters affecting ungulate locomotion in snow (Telfer and Kelsall 1979).

- energetics and mechanics of terrestrial locomotion (Taylor et al. 1981).

STRESS INDUCED BY HUMAN ACTIVITY TO WILDLIFE SPECIES PRESENT IN WINTER IN YELLOWSTONE NATIONAL PARK

Bald Eagles

- human disturbance adversely affected wintering bald eagle distribution and behavior. Distribution patterns were significantly changed, resulting in displacement of eagles to areas of lower human activity, simulated disturbances of persons afoot, in Washington state (Stalmaster and Newman 1978).

- human disturbance is most serious for eagles that depend on large fish or mammal carcasses as their major food source (Anthony et al. 1995).

- human disturbance is an important factor in nest site selection by bald eagles (Murphy 1965).
- modeling cumulative effects of humans on bald eagle habitat (Montopoli and Anderson 1991).
- in Washington state, sensitivity of wintering bald eagles to human disturbance (Russell 1990).
- human disturbance of an avian scavenging guild; includes eagles (Skagen 1980; Skagen et al. 1991).
- human activities had adverse effects on distribution and behavior of wintering bald eagles in Washington state; measured flight distances from simulated human disturbances (Stalmaster and Newman 1978; Stalmaster et al. 1993); high levels of human disturbance during winter could increase energy demands and result in increased mortality rates (Stalmaster and Gessaman 1984).

Bighorn Sheep

- harassment led to increased energy expenditures and was most damaging when animals were in poor condition (Geist 1971).
- at Grand Canyon, studied helicopters and sheep time budgets; frequent alerting affected food intake (Stockwell et al. 1991).
- in Wyoming, all mountain recreationists may stress sheep that they encounter (Thorn et al. 1979).
- harassment has significant impacts on individuals and populations and reduces fitness; passive harassment produces no visible response but may have psychological and physiological effects on sheep (Horejsi 1976).
- in California, human disturbance by recreationists may be limiting sheep populations; measured heart rate responses to harassment (Stemp 1983) (M.S. Thesis).
- cardiac and behavioral responses of bighorn sheep to human disturbance; heart rates varied inversely with distance from road (MacArthur et al. 1982).
- in Rocky Mountain Park, disturbance in critical sheep habitats has been reduced by closure of trails (Stevens 1982).

Black Bears

—— assessed the effects of recreational activities on denning ecology of 19 bears for 3 winters in Nevada and California; “data implied that protecting black bear denning areas from human disturbance in winter is important to minimize cub abandonment and needless energetic expenditures by increased winter activity” (Goodrich and Berger 1993).

Canada Geese

—— Geese seemed to avoid or leave locations where disturbances restricted feeding (Austin 1988) (Ph.D. Thesis).

Coyotes

—— abortion and consumption of fetuses by coyotes following abnormal stress (Gipson 1970).

Elk

—— people concentration areas should be one-half mile from elk feeding sites in Wyoming (Ward et al. 1973).

—— positive correlation of man-caused disturbance and elevated heart rates in telemetered elk; highest incidence occurred with loud noises and direct interaction (Ward 1977).

—— nutrition during gestation in relation to successful reproduction (Thorne et al. 1976).

—— in Yellowstone Park, “recurring long periods of limited areas, such as at campsites, appeared to cause limited shifts in elk distribution” (Chester 1976) (M.S. Thesis).

Other Wildlife

—— the physiology of alarm in deer mice (Rosenmann and Morrison 1974).

—— a 40kg unstressed pronghorn in winter would necessarily consume 900 grams dry matter/ day for maintenance and growth. . . 32% higher for animals which were moderately active, and variably increased by cold temperatures (Wesley et al. 1973).

—— how close certain passerine birds will tolerate approaching humans (Cooke 1980).

—— human disturbance of an avian scavenging guild (Skagen 1988; Skagen et al. 1991).

General

—— ecosystem behavior under stress (Rapport et al. 1985).

— "In contrast to sizeable literature of direct effects on wildlife, very few studies have documented impacts resulting from habitat changes induced by recreational activities; . . .the indirect effects of recreation on animal populations are likely to be substantial, but there is little rigorous documentation of these impacts. For invertebrates, amphibians, reptiles, small birds, small mammals, and many fish, these indirect effects are likely to be more substantial than direct impacts of recreationists" (Cole and Landres 1995:192-93).

— snow-based recreation may result in facility construction, fragmenting and reducing the availability of critical habitat; of the snow-based recreational activities, "the impacts of snowmobiling appear to be most pronounced" (Cole and Landres 1995:186).

— "When people intrude into wildlife habitat, stress on populations is one result. Snowmobile activity is a particular problem as people move into wintering areas where animals may already be stressed;. . . animals can be stressed to the point that they require more energy than they can take in, so they must rely on body reserves. Continuous stress from human recreation could eventually cause illness or death of an animal (p. 163); . . ."continuous harassment of animals causes them to expend energy beyond what they can take in during the winter, so some animals can die or fail to reproduce. Stress has been shown to be an important contributor of declining populations in some animals but such population related work is rare" (Anderson 1995:166).

— "From a legal point of view, harassment includes behaviors that indicate an animal has heard a sound, as well as behaviors that indicate aversion;. . .any human-made sound that alters the behavior of animals or interferes with their normal functioning: from a legal point of view constitutes a taking (*e.g.*, Endangered Species Act of 1973; Marine Mammal Protection Act of 1972. (p. 109, Bowles 1993).

— "In polar regions, many animals must rely on stored body reserves and on maintaining low levels of activity to survive winter. Increased human activity in these areas due to increased tourism or industry, for example, will certainly affect their behavior and physiology" (Gabrielson and Smith 1995:104-05).

— at the wildlife community level, "Our understanding of how recreational activities influence communities is just developing. . .;recreationists can directly alter competitive, facilitative, and predator-prey relations, three types of interaction that have the potential to affect community structure and dynamics. Species richness, abundance, and composition in communities can be altered by displacement and through the indirect effects of recreationists on habitat structure. . . Species that are sensitive to the presence of people may be displaced permanently; accordingly, Hammitt and Cole (1987:87) ranked displacement of wildlife as being more detrimental to wildlife than harassment or recreation-induced habitat changes (p. 173). Depending on the species that are lost or the interspecific interactions that are uncoupled by displacement, the presence or abundance of other species may also be affected (Gutzwiller 1995:177).

- nonconsumptive users of wildlife do not exist; gives examples of adverse impacts on wildlife from recreationists and scientists (Weedin 1981).

- the concept that some outdoor recreational activities are nonconsumptive is rejected; includes human impacts on wildlife (Wilkes 1977).

- in national parks, managers must realize that these areas have a finite capacity for absorbing human disturbances such as sightseeing, that may alter energy pathways, disturbing vegetation and wildlife (Houston 1971).

- the physiology of fear and anxiety in man and other animals; physiological and behavioral responses to disturbance; a reference book (Mayes 1979).

- “The adaptive characteristics of wildlife, the recreationists behavior, and the context of the disturbance all seem to be important” (Roggenbuck 1992).

- ecosystem behavior under stress (Rapport et al. 1985).

- trends expected in stressed ecosystems (Odum 1985).

- discussed environmental effects of off-road vehicles, particularly snowmobiles. “Clearly the effective way to protect fish and wildlife is not by restricting hunting or harassment alone, but by banning these vehicles from important habitats” (p. 25); harassment caused an unusual number of abortions in wild animals (Baldwin 1970).

- in Yellowstone Park, elk, bison, coyote, mule deer, and moose in that order, were the most frequently encountered wildlife. Wildlife developed crepuscular activity patterns, some displacement from areas adjacent to trails occurred, movement across trails was inhibited by traffic and by the berm created by plowing and grooming operations. Harassment of wildlife by snowmobilers and skiers increased energy expenditure by wildlife. Effects of winter recreationists on the physical environment included minor air and snow pollution by snowmobile exhaust, litter, noise pollution, and limited physical damage to soils and plants. Study area was portions of Madison, Firehole, and Gibbon River valleys (Aune 1981) (M.S. Thesis).

ROADS

Bald Eagles

- in Washington state, wintering eagles initially used areas isolated from a road and receiving little human use, and only when food became less available in these areas eagles utilized areas having more human activity (Serveen 1975) (M.S. Thesis).

Bears

- in Mt. McKinley Park, some bears were attracted to the park road (Tracy 1977) (M.S. Thesis).

- in Yellowstone Park, bears appear to avoid carrion near occupied roads; there has been some springtime avoidance by emerging bears of the area (and available carrion) within 3 miles of the Old Faithful developed area and within 0.25 miles of active roads in the Firehole and Gibbon valleys. (Bear species not specified). (USDI National Park Service 1990:64).

- in Banff, Yoho and Kootenai Parks, the GIS system was used to analyze locations of radio-collared grizzly bears with respect to roads, trails, and ski areas. Carnivore migration corridors must be preserved or widespread habitat alienation can occur (Purves et al. 1992).

- in Yellowstone, in 1995, 6 black bears were known to have been hit by vehicles, one of which is known to have died; no grizzlies were known to have been hit by vehicles (Anon. 1996).

Bighorn Sheep

- in Alberta, heart rates of bighorns varied inversely with distance from road (MacArthur et al. 1979).

- in Rocky Mountain Park, trail closures have reduced visitor use of critical sheep habitats, reducing disturbance of sheep (Stevens 1982).

- in Alaska, bighorn sheep that occupy ranges away from the Denali Park Road must cross the road during seasonal migrations, but have not habituated to traffic even though the road has been there for 54 years (Dalle-Molle and Van Horn 1991).

Bison

- in Yellowstone and Grand Teton Parks “Bison. . .travel on groomed and plowed roads” (USDI, National Park Service 1990:62).

Deer

- on winter ranges in Colorado, deer avoided areas near roads, particularly within 200 meters of roads (Rost 1975) (M.S. Thesis).

— in Washington state, deer showed a general reduction of use up to 1/8 mile from roads, depending on amount of roadside cover; deer were substantially affected in meadows where roadside cover was lacking (Perry and Overly 1976).

— quantified impacts on deer of management activities including roads (Thomas 1979).

Elk

— on winter ranges in Colorado, elk avoided areas near roads, particularly within 200 meters of roads (Rost 1975) (M.S. Thesis).

— construction of roads in elk habitat effectively eliminated prime area from elk production (Pederson 1979).

— in Idaho, road closures allowed elk to remain longer in preferred areas (Irwin and Peek 1979).

— in Glacier Park, habituation to roads made elk more vulnerable to poaching (Singer 1975).

— in Yellowstone Park ". . .elk . . .travel on groomed and plowed roads" (USDI, National Park Service 1990:62).

— human activity on forest roads alters distributions of Roosevelt elk activity; monitored 6 cows for one year (Witmer and deCalesta 1985).

Foxes

— in Mt. McKinley Park, some foxes were attracted to the park road (Tracy 1977) (M.S. Thesis).

Moose

— in Yellowstone and Grand Teton Parks, "moose travel on groomed and plowed roads" (USDI, National Park Service 1990:62).

Mountain Lions

— in Arizona and Utah, lions selected home areas with lower road densities (Van Dyke et al. 1986).

Wolves

- on Isle Royal, wolves avoid contact with humans; management suggestions include limiting visitation, no further trail development and discouragement of winter visitor use (Peterson 1977).

- in Banff, Yoho, and Kootenai Parks, the GIS system was used to analyze locations of radio-collared wolves with respect to roads, trails, and ski areas. Wolves showed aversion to areas where human use exceeded 10,000 visitors per month (Purves et al. 1992).

- in Jasper Park, wolves tend to avoid traveled roads (Carbyn 1974).

- describes interrelationships of wolves, prey, and man in Alaska (Gasoway et al. 1983).

- in Kenai NWR, Alaska, radio-collared wolves avoided roads open to the public but used other roads with limited human use; management plans for wolves may include reduction of roads and seasonal or permanent gating of roads to reduce human access (Thurber et al. 1994).

General

- in Mt. McKinley Park, among ungulates, "females with young were the most easily disturbed by human activity on the park road" (Tracy 1977) (M.S. Thesis).

- when trails are developed, "discarded human food wastes provide different sources of food for animals, affecting their population structure"(Anderson 1995 citing Knight and Cole 1991).

THERMAL AREAS

Bald Eagles

- in Grand Teton and Yellowstone Parks, "a relationship seems to exist between open water and nest site selection. . .Thus 87% of the nesting territories were located either in major rivers, or lakes within 5 km of their inlets or outlets, or <u>along streams or lakes in thermal areas</u>" (Alt 1980:40) (M.S. Thesis). (emphasis added).

- in the Greater Yellowstone Ecosystem, the primary wintering areas are along major rivers, usually near concentrations of wintering ungulates and open water where waterfowl and fish are available. Thus, food availability appears to determine bald eagle use of an area during winter (p. 38). <u>Thermal areas</u> keep some waters open in Hayden and Pelican Valleys and small portions of Lewis and Heart Lakes, which give bald eagles access to wintering waterfowl and fish (Swensen et al. 1986) (emphasis added).

— in Yellowstone, in winter, “Eagle activity is greater along streams that remain ice-free and in thermal-influenced areas. . .” (USDI National Park Service 1990:12) (emphasis added).

— in Yellowstone, there are 19 active territories and eagles “can be seen year round in the park, nesting usually in riparian zones along the Madison and Yellowstone rivers where raptors can find fish at any time of year in thermally influenced open waters (p. 5) . . .eagles also scavenge on the carcasses of winterkilled elk and bison, particularly on the northern range and in the Firehole Valley” (Anon. 1995:6) (emphasis added).

Bison

— in Yellowstone Park, “The survival factor, for bison in parts of Yellowstone, may be the existence of thermal areas. As previously discusses, thermally active areas do not attract large numbers of bison for the winter, but the use of certain areas for brief periods, particularly at times of prolonged cold combined with heavy snow depth, as observed by Jim Stradley, or in late winter as seen during the study period may determine the lower limit to which the population numbers drop. . .where winters are more severe, those valleys which have bison have either extensive thermal or warm areas, or else many small ones among which movement is possible. Some streams which remain unfrozen because of an influx of warm water are an additional feature of most wintering areas. . .” (Meagher 1970) (Ph.D. Dissertation) (emphasis added).

— “Total use by bison of all areas where thermal influences alleviated otherwise more severe winter conditions was more than the use of thermally active sites. In the three valleys of Hayden, Pelican and the Firehole the amount of bison use made of sedge bottoms with lessened snow depths, and the ice-free streams indicated that thermal influence was important in maintaining wintering populations (p. 100) (Meagher 1970) (Ph.D. Dissertation) (emphasis added).

Elk

— in Yellowstone, elk habitat along the Madison, Firehole and Gibbon rivers has deeper snow than the northern range; consequently thermal areas with snow-free vegetation or shallow snow are very important to winter habitat for elk (USDI National Park Service 1990:10).

Trumpeter Swans

— in Yellowstone Park, “Snowmobile and ski trails should be routed away from river courses” (Shea 1979) (M.S. Thesis).

—— in Yellowstone, "Trumpeter swans remain in the area year-around and are joined by winter migrants. About nine pairs nest in Yellowstone, and in winter the population increases to somewhere between 40 and 300, depending on the number of migrants spending at least part of the year there. . .The slow flowing open water habitat required for swan survival is increased by thermal activity, but even in Yellowstone it becomes scarce during the coldest part of the winter: (USDI National Park Service 1990:16). (emphasis added).

General

—— in discussing indirect effects of recreation on wildlife, "The vulnerability and variety of the habitat, and its importance to wildlife, should also be considered" (Cole and Landres 1995:183). (emphasis added).

—— "In the long term, if extensive habitat alteration occurs for animals that have a limited distribution, the population of a particular species may experience substantial declines" (Anderson 1995:157).

ENERGETICS AND NUTRITION OF WILDLIFE IN WINTER

Bears

—— in Yellowstone, available food for grizzly bears . . .is the greatest threat to survival of the bear population; increasing recreational activities in the Yellowstone area will increase this problem (Knight et al. 1988).

—— grizzlies commonly scavenged in dead elk; total elk mortality in study area of Firehole, Madison and Gibbon River drainages in winter-spring 1969-70, was 268 elk; in Yellowstone Park's Firehole, Madison and Gibbon River drainages, grizzly bears culled elk with low energy reserves (Cole 1972).

Bighorn Sheep

—— prediction of energy expenditures by bighorn sheep (Chappel and Hudson 1980).

Bison

—— in Yellowstone Park, bison "Use of the plowed road for relatively easy and energy-efficient travel probably facilitated learning and a rapid increase in numbers" (Meagher 1989:674). Author here was referring to the plowed road between Tower and Mammoth, where daily road plowing began in the late 1940s.

— in Yellowstone Park, in Hayden, Pelican and Firehole Valleys ". . .thermal influence was important in maintaining wintering populations" of bison (p. 100), sites of thermal influence "were of great importance to the bison population during brief but critical periods" (p. 100). "In spite of limited use, these areas probably represent the margin of survival of the herd groups in Firehole, Hayden, and Pelican Valleys during the most extreme winter conditions" (p. 101). "The survival factor, for bison in parts of Yellowstone, may be the existence of thermal areas" (p. 111), and ". . .thermally active areas do not attract large numbers of bison for the winter, but the use of certain areas for brief periods, particularly at times of prolonged cold combined with heavy snow depth. . . or in late winter. . . may determine the lower limit to which population numbers drop" (p. 112) (Meagher 1970) (Ph.D. Dissertation).

— in Yellowstone Park, winter weather is a population regulating influence on bison (Meagher 1976).

— in Yellowstone Park's Madison-Firehole range, in winter, progressive nutritional restriction in bison was greater than on the northern range or in Pelican Valley (DelGuidice et al. 1994).

Elk

— in Yellowstone Park, assessed nutritional deprivation of cow elk groups on northern range and Madison-Firehole range and estimated elk density and calf:cow ratios. Found significant declines in calf:cow ratios from early to late winter were associated with nutritional deprivation, particularly in areas of high elk density and/or deep snow (DelGuidice et al. 1991).

— passive harassment of elk resulting from human activities caused overgrazing of marginal habitats, which may be especially harmful to elk during severe winters when their energy budgets are stressed (Morganti and Hudson 1980).

— telemetered heart rates of elk affected by human disturbance (Ward and Copal 1980).

— effects of nutrition during gestation in relation to successful parturition in elk (Thorne et al. 1976).

Moose

— seasonal energy expenditures and thermoregulatory responses of moose (Renecker and Hudson 1986).

— the metabolic rate of moose during winter (November to March) was similar to values reported for other wild ungulates; tame moose; Alaska (Regelin et al. 1985).

Mule Deer

- urine cortisol measurement in winter provide a tool for assessing population condition in mule deer (Saltz and White 1991).

White-tailed Deer

- lowest ecological metabolism in white-tailed deer occurs in winter; an adaptation for energy conservation. Resource needs lower when range resources are reduced. The timing of spring arrival is important to population dynamics, with effect pronounced 2 years later when fawns become breeders (Moen 1978).

General

- "During winter, processes influencing energy intake, rather than energy expenditure, have a much greater impact on energy balance of ungulates (Hobbs 1989), suggesting that disruption of wildlife while feeding is of greater concern than causing wildlife to flee. Mammals show a weaker response to humans during the winter months than at other times of the year. Hamr (1988) reported that chamois were least sensitive to recreationists when snow was deep, forage was inaccessible, and energy conservation was decisive to survival" (Knight and Cole 19959:73-74).

- discusses maintenance metabolism in herbivores (book) (Hudson and Christoperson 1986).

- the energetic cost of cratering (digging) through uncrusted snow (by caribou) was 118 Joules/stroke, whereas that cost was 481 Joules/stroke when cratering through snow compacted by a snowmobile (Fancy and White 1985).

NOISE

Birds

- seem to habituate more rapidly to mechanical noise than to human presence (Gabrielsen and Smith 1995:104).

Deer

- seem to be considerably more tolerant of noise than deer are (Bury 1978).

Elk

- seem to be considerably less tolerant of noise than deer are (Bury 1978).

Fish

— detection and reaction of fish to infrasound (Enger et al. 1993).

Mice

— effects on blood eosinophil levels and adrenals of mice (Anthony and Ackerman 1995).

General

— effects of snowmobile noise on large game animals appear to vary by species (Bury 1978).

— data for domestic and laboratory animals were extrapolated for wildlife; potential effects included masking of signals and calls; chronic exposure could result in physiological and behavioral changes; effects would most likely be cumulative (Dufour 1971).

— hearing in vertebrates, a psychophysics data book (Fay 1988).

— effects of noise on wildlife; quantifying the acoustic dose when determining the effects of noise on wildlife; a perspective of government and public policy regarding noise and animals (a book) (Fletcher and Busnel 1978).

— mammals habituate more rapidly to mechanical noise than to human presence (Gabrielsen and Smith 1995:104).

— noise effects on wildlife (Tennessee State Univ. 1971).

— presents an animal response model to quantify effects of noise on wildlife (Janssen 1978).

— a method for measuring wildlife noise exposure in the field (Kugler and Barber 1993).

— effects of noise on wildlife and other animals; sources potentially disturbing to wildlife include recreational vehicles (U.S. Environ. Protection Agency 1971).

— effects on wildlife (Bollinger et al. 1973).

— reviews recreational noise influences on wildlife, including snowmobiles; “. . .noisy vehicles will affect them at much greater ranges than humans. However, if they are habituated to vehicle noise at levels that are not aversive, humans laughing and yelling can arouse responses at greater ranges than snowmobiles (p. 113). With repeated exposure, all vertebrates habituate or adapt behaviorally and physiologically. . .One form of adaptation is sensitization (an increase in responsiveness) resulting from negative experiences associated with noise; vertebrates from fish to mammals can learn to avoid noise associated with danger. . .Motivations such as hunger that keep animals from paying attention to noise lessen its aversiveness. . .Guidelines that protect human hearing apply to many terrestrial mammals because they are based on studies of laboratory animals (p. 115). Noise can doubtless affect communication and sleep in animals. Noise is suspected of causing stress-related illness in both humans and animals. . .Wild animals can abandon favored habitat in response to disturbances or incur energetic expenses after reacting. . .Masking and hearing loss represent a life-threatening hazard in predator-prey interactions. . .noise might cause animals to become irritable, affecting feed intake, social interactions, or parenting. All these effects might eventually result in population declines. Even if populations were unaffected, genetically determined differences in susceptibility might exert subtle selection that eventually could affect fitness." Each of these potential effects is considered in detail (p. 116) (Bowles 1995).

WILDLIFE HABITAT CORRIDORS

- importance of migration between fragments of nature reserves (Burkey 1989).
- habitat patch connectivity and population survival (Fahrig and Merriam 1985).
- the need for movement corridors (Harris and Gallagher 1989).
- dispersal and connectivity in metapopulations (Hansson 1991).
- ecological considerations in the design of wildlife corridors (Lindenmayer and Nix 1993).
- consequences and costs of wildlife corridors (Simberloff and Cox 1987).
- effects of habitat fragmentation on extinction (Wilcox and Murphy 1985).
- for cougars (Beir 1993).
- in Colorado, <u>mule deer</u> migration was strongly correlated to winter severity; demonstrated strong fidelity to winter ranges; fidelity to individual movement patterns is long range, possibly for life (Garrott et al. 1987).
- carnivore habitat corridors must be preserved or widespread habitat alienation can occur for <u>wolves</u> and <u>grizzlies</u> in Yoho, Kootenai and Banff National Parks (Purves et al. 1993).

POLLUTED SNOW

- polluted snow in southern Norway, in winter (Elgmark and Langeland 1973).

— polluted snow effects on freshwater and aquatic organisms (Hagen and Langeland 1973).

— lead emissions from snowmobiles as a factor in lead contamination of snow (Ferrin and Coltharp 1974).

— snowmobile engine emissions and their impact (Hare and Springer 1974).

— in Minnesota, a study of small mammals indicated that snowmobile use may trap toxic air in snow (Jarvinen and Schmidt 1971). (Also see "Snomobiling - Subnivian Mammals/ Small Mammals" section of this report).

— "Pollutants produced by recreational activities (*e.g.*, gasoline and oil leaked by off-road vehicles) or sewage effluent may take considerable time to flow into groundwater or be flushed from the soil surface to streams or lakes" (Cole and Landres 1995:191).

— contamination of vegetation by tetraethyl lead (Cannon and Bowles 1988).

APPENDIX II. POTENTIAL OPPORTUNITY AREAS

Potential Opportunity Areas (POA) are lands in the Greater Yellowstone Area that possess the physical and social conditions desired by various winter recreationists. POAs describe an area's recreation potential, not necessarily its existing condition. The experiences range from those that are easily accessible and highly developed (such as snowmobiling to Old Faithful) to those that are considered remote backcountry experiences (such as skiing in the Absaroka-Beartooth Wilderness). These areas are mapped in *Winter Visitor Use Management: A Multi-agency Assessment, Final Report of Information for Coordinating Winter Recreational Use in the Greater Yellowstone Area*, Greater Yellowstone Coordinating Committee, 1999.

Each of the descriptions below includes some of the most important attributes that the opportunity area should possess, setting it apart from the others. Though the names of the opportunity areas are primarily reflective of snowmobile and ski activities, other recreation uses such as ice climbing, trapping, hunting, ice fishing, photography, dog sledding, using snowplanes, and four-wheel driving could be appropriate in various opportunity areas. The activities that could be accommodated in each area depends on the mutual compatibility of the activities and the social and environmental conditions necessary to support quality recreational experiences, while protecting wildlife and other resources. For example, in many "groomed motorized routes" (Opportunity Area 4), cross-country skiing and other nonmotorized activities could occur. In "groomed nonmotorized routes" (Opportunity Area 7), many different activities could occur, but motorized activities would not be compatible.

Comparative use levels are described for each opportunity area. For example, the use level considered consistent with "groomed motorized routes" (Opportunity Area 4) is described as "high" while the use level for "motorized routes" (Opportunity Area 5) is described as "moderate." More detailed analysis, beyond the scope of this assessment, will be required to quantify the actual numbers that constitute "high" or "moderate" use. Existing use levels vary widely in different areas that might be allocated to the same opportunity area classification. The team emphasizes that the described use levels represent the *upper limits* that resource managers believe are compatible with quality recreational experiences. It is neither expected nor desired that all areas reach the upper use limits.

1. DESTINATION AREAS

These are highly developed, highly used hubs of concentrated recreational use on public lands or lands under permit by public agencies. Located on travel routes, these areas provide support services for a wide variety of activities and may include lodging, food services, instruction, and interpretation. Destination areas may be staging and access points for recreational activities serving a fairly large surrounding area. Multiple uses are expected to occur, and some use conflicts are tolerated as are some resource impacts. (This analysis does not include towns, cities, and communities; they appear on the base map for reference purposes only.)

2. PRIMARY TRANSPORTATION ROUTES

These are highways open year-round and used for commercial as well as recreational traffic. Primary transportation routes have a recreational component, such as accessing trailheads and winter use destination areas, but are primarily travel corridors.

3. SCENIC DRIVING ROUTES

Forest and park visitors use these roads primarily to enjoy the surrounding area scenery, to access trailheads, and to access winter use destination areas. The roads are open all year to wheeled vehicles, but generally carry less traffic than the primary transportation routes. Because viewing scenery and wildlife, and enjoying the drive are the primary experience for many users, visual quality and clean air are important. Some sound associated with highway travel is tolerated.

4. GROOMED MOTORIZED ROUTES

Along these routes, motorized and nonmotorized activities occur in safe, highly maintained corridors and traverse a variety of settings. Destinations and attractions along the way are of high interest. Appropriate developments could include restrooms, warming huts, food services, interpretive facilities, gas stations, and other conveniences. Terrain on the groomed surface is gentle and suitable for novices. Smooth, groomed snow surfaces are important. High use levels are expected, and relatively more sound is tolerated than in the other opportunity areas.

5. MOTORIZED ROUTES

Generally routes are well-marked and relatively safe corridors for motorized and nonmotorized activities. Included in this opportunity class are moderate- to high-density snow play areas. Facilities are usually limited to those located at trailheads. Some of these routes may be distant from access points and roads, but these are not places where one is likely to get lost. Greater skill levels are required here than on groomed routes because snow surfaces are not expected to be as smooth. Varied terrain is desirable for moderately challenging experiences. Moderate use levels are expected, and while some snow machine sound is tolerated, it is generally expected to be more intermittent than the relatively constant sound along the groomed routes. These routes may be groomed but not to the standards of POA 4.

6. BACKCOUNTRY MOTORIZED AREAS

These combine marked but ungroomed motorized routes and low- to moderate-density snowmachine play areas. Challenge and adventure are important. Little in the way of support facilities, other than parking at access areas, is needed. Use levels are low to moderate. Moderate to high levels of remoteness are desirable, as are scenic views, challenging terrain, deep snow, and untracked powder. Intermittent noise is tolerated. Users need experience and skill for a safe outing.

7. GROOMED NONMOTORIZED ROUTES

People come for nonmotorized experiences in safe and often well-maintained corridors. These areas are used as much for exercise and race training as for recreation, but they are suitable for beginners where the terrain is gentle. Nearby support services are desirable and may include restrooms, trailheads, informational and directional signing, instruction, lodging, and warming areas. Fairly high use levels are expected. Sound and visual evidence of other nearby activities and from adjacent opportunity areas are tolerated but not desirable.

8. NONMOTORIZED ROUTES

Park and forest visitors use ungroomed nonmotorized routes to ski or snowshoe in a natural setting on routes that are apparent but not necessarily marked. Developments in these areas are limited to access points and parking. Gentle topography provides interest but not a high level of challenge. Consistent snow is important, but various snow conditions are tolerated. Low to moderate use levels are expected, but a high level of sound is disruptive to the experience. Outings are generally one day or shorter in duration, although rental cabins may be the destination along some routes.

9. BACKCOUNTRY NONMOTORIZED AREAS

These provide backcountry experiences characterized by remoteness and freedom from development and other human traces. Solitude, low use levels, and absence of noise are important elements of this experience. Terrain is varied and provides moderate to high levels of challenge and adventure. Backcountry and route-finding skills are required for a safe outing. Outings may be more than one day in duration.

10. DOWNHILL SLIDING (NONMOTORIZED)

Users of these areas are looking for challenge, adventure, and opportunities to improve skiing and snowboarding skills. While absence of crowds, developments, and regulation are important to this experience, moderate use levels are tolerated. Untracked snow provides the ultimate satisfaction for these users. Quiet is desirable, but some sound from nearby activities may be tolerated. The best areas are close to access points.

11. AREAS OF NO WINTER RECREATIONAL USE

These are areas where administrative closures protect wildlife winter range and other lands not managed for recreation, or where use is prohibited because of sensitive resources, such as thermal features.

12. LOW-SNOW RECREATION AREAS

Low-snow and snow-free conditions during much of the winter characterize these areas. Hiking, fishing, hunting, bird watching, mountain biking, or ATV riding and 4-wheel drive activities if consistent with travel management plans are common activities that could occur. If snow is present motorized activities occur in designated routes consistent with travel management plans. Snow related winter uses are appropriate unless otherwise regulated.