EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE
A Review for Montana

MONTANA CHAPTER OF THE WILDLIFE SOCIETY

www.montanatws.org

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FOREWORD

In his 1948 preface to *A Sand County Almanac*, Aldo Leopold made a statement that embodies the spirit and commitment that motivated and guided this project:

> ***We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect. There is no other way for land to survive the impact of mechanized man, nor for us to reap from it the esthetic harvest it is capable, under science, of contributing to culture.***

The wildlife professionals who volunteered their time and energy to this project and the conservation organizations and resource agencies that funded it exemplify dedication to stewardship of wildlife communities. The effort that culminated in this document was prompted by a proliferation of various types of recreational activities on the nation's public lands. There is growing concern among resource professionals and wildlife advocates that implementation of recreational developments and approval of recreational activities has too often occurred in the absence of adequate information, planning, or design. Without accurate and adequate information and planning, projects may have been implemented at the expense of wildlife resources. Resource management and regulatory frameworks currently in place did not anticipate the unprecedented pace at which recreation is being developed, the technological advances that have resulted in new types of recreational pursuits, trends in relative popularity of various types of recreational activities, or the sheer numbers of participants.

Resource professionals developed this reference for use by resource managers and decision makers as well as the general public. This document recognizes the complexity of ecosystem management issues and acknowledges that a resource manager or decision maker cannot be an expert in all arenas. This project also recognizes that citizen stakeholders in the stewardship of wildlife resources need information that will help them provide informed comments during decision-making processes. It is our hope that the use and periodic updating of this report and bibliography will foster good decision making in the face of pressures on resource managers and decision makers by competing interests. To achieve that goal, we focused our energies on finding and compiling the best information available and making it readily accessible to the general public in a user-friendly format.

We acknowledge that our work product is not complete in all respects. It is the product of a volunteer work effort that was completed in large part on personal time. Competing demands on the individuals who contributed to this ambitious project precluded attainment of our highest aspirations. However, this project achieved a significant advancement in the accessibility of information relevant to important issues facing resource managers and citizen stakeholders. It is our hope that this reference be used to foster good stewardship of Montana's wildlife resources for current and future generations. We urge our colleagues and members of other professional societies to augment and update the base of knowledge that we have compiled to ensure that future editions of this reference will continue to provide the accurate and up-to-date information needed for decisions pertaining to development of recreational activities on Montana's public lands. In the long-term, this is what is necessary to sustain wildlife on our public lands.

ACKNOWLEDGEMENTS

> ***Never doubt that a small group of committed individuals can change the world. Indeed that is the only thing that ever has.*** **~~ Margaret Mead ~~**

In March 1997, the executive board of the Montana Chapter of The Wildlife Society (MCTWS) created a "committee on recreation in wildlife habitat" by executing a position statement adopted by the Chapter membership at its annual meeting (Appendix A). The Committee has been a dynamic entity, evolving since its inception. The cadre of MCTWS members who contributed to this project deserve praise for their commitment and determination.

Thirty Committee members compiled sections of this report, while more than 30 others participated in meetings, annotated papers, and/or edited portions of the report. Authors, contributors, and editors are acknowledged at the beginning of each chapter. Sincere appreciation is extended to those who stepped forward to assume chair positions: L. Jack Lyon/Jodie Canfield (ungulates), Gene Hickman (small mammals), Bryce Maxell/Grant Hokit (amphibians/reptiles), Betsy Hamann/Heather Johnston (birds), Jim Claar (carnivores), Amy Waller (semi-aquatic mammals), and Kriss Douglass/Gayle Joslin (vegetation/soils/water). Chapter officers spanning four board terms provided enthusiasm, encouragement, and financial support and have expressed a commitment to carry this effort forward.

Several individuals provided invaluable logistic services: Beth Kaeding copy edited the manuscript, and Sally Sovey assembled and electronically finessed the document. Amy Waller, the consultant retained by the committee, provided her services at a bargain price and volunteered time in addition. Martha Lonner and Marcia Leritz of Media Works, provided cyber-knowledge pertaining to maintaining the bibliography and report online, the logistics of downloading and printing, as well as the artful report covers and brochure design. Duane Anderson, Montana Natural Resources Information Services, designed the repository for the bibliography to which the MCTWS web site is linked. Don Cornish of the Montana State Library agreed to house, catalogue, and loan hard copies of bibliography references. Design and display of the prototype bibliography on the Montana Fish, Wildlife & Parks web site is gratefully acknowledged.

Financial support in the amount of $33,700 was provided by 10 non-profit organizations, some of which were multiple contributors. State and federal agencies provided support in the amount of $40,000, bringing the total funds donated to the project to $73,700. Sincere appreciation is extended to all supporters in the private and public sectors who believed that this project was both needed and feasible and that a cadre of volunteers could complete it.

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Among project volunteers, co-chair Gayle Joslin coordinated fundraising, project schedules, the volunteer effort, and logistics of producing final products. Co-chair Heidi Youmans assisted the annotation, information compilation, writing, and editing phases of the project. Special recognition is extended to the following individuals for their assistance in the completion of this project: Bob Walker and Don Childress, Montana Fish, Wildlife and Parks; Jim Claar and Marion Cherry, Northern Region, U.S. Forest Service; Dave McCleerey and Bob Haburchak, Bureau of Land Management; Mike Hedrick, C.M. Russell Wildlife Refuge, U.S. Fish & Wildlife Service. Important critical review and encouragement was provided by Jim Posewitz, Cinnabar Foundation, who supported this effort in several ways.

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A=Semi-Aquatic Mammals; B=Birds; C=Carnivores; H=Herptiles; S=Small Mammals; U=Ungulates; V=Vegetation
Underlined Name = Sub-committee Chair

BOARD of the MONTANA CHAPTER of THE WILDLIFE SOCIETY

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PROJECT OVERVIEW

The Wildlife Society (TWS) is an international professional society established in 1937. The Society's membership of more than 9,600 includes research scientists, educators, communications specialists, resource managers, conservation law enforcement officers, administrators, and students in more than 60 countries. The principal objectives of The Wildlife Society are: (1) to develop and promote sound stewardship of wildlife resources and of the environments upon which wildlife and humans depend; (2) to undertake an active role in preventing human-induced environmental degradation; (3) to increase awareness and appreciation of wildlife values; and (4) to seek the highest standards in all activities of the wildlife profession.

The Montana Chapter of The Wildlife Society (Montana Chapter, TWS) has a membership of 310. Montana Chapter, TWS members who actively contributed to this project included individuals employed by state and federal agencies, educational institutions, non-profit organizations, industry, and consultants, as well as retirees and graduate students.

This project includes four elements:

1. A partially annotated bibliography relevant to effects of recreation on wildlife and wildlife habitats.
2. Species-group chapters and appendices that outline factors that should be considered in planning and managing recreation including, wherever possible, the status of existing knowledge of potential effects of recreation on wildlife. Species chapters address the following 6 species groups: amphibians and reptiles, birds, small mammals, semi-aquatic mammals, ungulates, and carnivores. The report also includes a chapter on vegetation soils, and water as well as a chapter on potential effects of companion dogs.
3. Proposed guidelines, supported by published literature, and committee recommendations are designed to guide the planning and management of recreation and recreational developments with consideration for wildlife values. Guidelines are summarized at the broad, general level in the project overview. Guidelines and/or recommendations specific to species groups are included in most species chapters.
4. A brochure for distribution to the general public that provides the Internet address of the Montana Chapter, TWS bibliography and report and summarizes recommended guidelines at a broad level.

PROJECT BACKGROUND

This project was prompted by growing concern among wildlife professionals and within the conservation community about potential effects of recreation on wildlife and the habitats that sustain wildlife. This concern has been fueled by a proliferation of technological advances in motorized forms of recreation, a growing array of recreational pursuits that are expanding their influence across the landscape, and the specter of substantial increases in numbers of participants as a result of population growth and recreational marketing. At its 1997 annual meeting in Missoula, the Montana Chapter, TWS adopted a position statement titled *Motorized Recreation in Wildlife Habitat* (Appendix A). This position statement focused on motorized recreation due to its prevalence and highly visible impacts. In addition to calling attention to trends in recreation and deficiencies in the implementation of many recreational development projects, the position statement called for a committee to be formed with the charge of "encouraging and assisting federal and state agencies to implement guidelines that address potential threats to wildlife and wildlife habitats."

A Montana Chapter, TWS Committee on Recreation in Wildlife Habitat convened in December 1997 to forge an approach in developing guidelines designed to address wildlife and habitat values. The purpose of guidelines is to provide a well-founded framework for incorporating wildlife values in the planning, implementation, and management of recreational activities and developments. At one of its early meetings, the Committee expanded the focus of its effort to include all forms of recreation – both motorized and non-motorized. The most visible potential impacts to natural resources are the result of high-impact activities such as off-road use of vehicles and personal watercraft (PWC). However, the committee recognized that other, non-motorized forms of recreation can also have substantial impacts on wildlife and wildlife habitats because of the sheer numbers of participants today (e.g., hiking, mountain biking, horseback riding, wildlife viewing, hunting). In addition, the Committee recognized that use of motorized vehicles in conjunction with other recreational pursuits, such as camping, fishing, and hunting, can result in synergistic and cumulative effects that have not traditionally been analyzed during planning processes or addressed by management frameworks. Our literature search emphasized terrestrial forms of recreation but included water-based and aerial forms of recreation, as well.

This project was not based on an assumption that recreation is inherently detrimental to wildlife or wildlife habitat. Rather it was undertaken with the recognition that any type of recreational activity or development, when uninformed, underplanned, underdesigned, inappropriately located, or unmanaged can result in substantial, detrimental effects to natural resources, including wildlife. A pervasive assumption that wildlife values are an automatic consideration in the planning and implementation of recreational developments has proven to be a vestige of the past, when many, if not most, forms of recreation in the field were likely to be wildlife-dependent, including hunting and trapping. The advent and growing popularity of recreational pursuits that are based on personal challenges and competition - including so-called "extreme" sports - require space, challenging terrain, and, in some cases, scenery. However, they do not require the presence of wildlife nor that wildlife populations are healthy or that ecosystems are intact and functional.

Resource management is in the midst of a paradigm shift (Knight and Gutzwiller 1995). A societal emphasis on recreation as the primary use of public lands has highlighted the significance of potential effects of recreational development, including cumulative effects. The fact that outdoor recreation is dispersed across large areas has contributed to a long-standing assumption that recreational activity has little environmental impact compared to extractive uses of natural resources. However, effects of recreation can be extensive for the very reason that they have been traditionally thought to be diluted, namely, recreationists <u>are</u> dispersed across large areas (Flather and Cordell 1995). Recreation that is not wildlife-based or dependent upon wildlife in any major way cannot be assumed to have been planned, implemented, or conducted in a manner that is sensitive to wildlife values. It is reasonable to assume that in most cases where impacts to wildlife resources have occurred on public land, such impacts were incidental and unintended on the part of the management agency as well as the users.

There is a growing realization that coexistence of wildlife with a growing human population indulging in an expanding array of recreational pursuits on a limited land base is contingent upon planning and management of both the recreational pursuits and wildlife needs at the landscape scale. Information is prerequisite to good planning and adequate management. Increasing numbers of resource managers and concerned publics have viewed the lack of easily accessible information pertaining to wildlife disturbance as a glaring need. A growing number of wildlife professionals and other wildlife advocates are objecting to the "Titanic" approach to emerging conflicts between recreation and wildlife values. Rather than discount or attempt to postpone risk factors in order to forge ahead on a previously established course, the Montana Chapter, TWS has produced this report and a partially annotated bibliography for the purpose of helping resource managers and resource users make an informed course correction. These references provide information required to plan and manage recreational activities and developments in a manner that considers wildlife values. Our ultimate goal is to have and to enjoy recreational opportunities that are compatible with long-term maintenance of healthy wildlife communities.

TRENDS IN RECREATION

As early as 1959, published literature refers to a "recreation boom," which 40 years later is <u>still</u> booming! The on-going recreation boom is largely a post-World War II (WWII) phenomenon fueled by population growth, increasing economic prosperity and technological advances in recreational equipment. During the 1960s, the jeep, the workhorse of WWII, was redesigned in a variety of four-wheel drive (4WD) models for recreational use. Also in the 1960s, motorcycle sales boomed, primarily because of technological improvements and the comparatively moderate cost of imported models from Japan. Trail-bike models, designed to operate on steep slopes and in rough terrain, emerged in the late 1960s. Earlier, during the 1950s, smaller versions of the cumbersome snow coach used to transport troops in WWII, were developed, and use of snowmobiles by recreationists took off in the late 1960s and early 1970s (Blackburn and Davis 1994). The all-terrain vehicle (ATV) appeared on the scene in the early 1970s.

The increasing popularity of off-road vehicle (ORV) use on federal lands during the 1960s and early 1970s prompted development of a unified federal policy for such use in Executive Order 11644 in 1972, and Executive Order 11989 in 1977 (GAO 1995). Concurrent with continued growth in use of 4WD vehicles (including sport-utility vehicles), trail bikes, snowmobiles, ORVs, motorboats, and downhill and cross-country skis, the popularity of snowboards, mountain bikes, float tubes, sailboards, personal watercraft, heliskiing, and river rafts has soared during the past 15 years. In recent years new forms of recreational activities have appeared on the Montana scene including ice boating, riverboarding, and amphibious ORVs. Indications are that use of amphibious ultra–light aircraft and hovercraft are in the offing.

In 1995, more than 94% of Americans engaged in some form of outdoor recreation at least once, an increase from 89% in 1982-83 (Cordell et al. 1997). Survey results included the following participation rates: walking (>66%), hiking (>23%), bicycling (30%), jogging (26%), off-road driving (14%), backpacking (8%), horseback riding (7%) and cross-country skiing (5%).

Between 1990 and 1998, the population of the United States is estimated to have increased 8 %, from 249,438,712 to 270,298,524 (U.S. Census Bureau). Between 1990 and 1998, the population of Montana is estimated to have increased 10%, from 799,830 to 880,453 (U.S. Census Bureau). Sixty-nine percent of the population growth that occurred in Montana between 1990 and 1997 has been attributed to migration (MFWP 1999). Montana's population is projected to reach 950,000 by the year 2000. Access to publicly owned lands where one can enjoy a variety of opportunities is integral to the widely envied "Montana lifestyle," and this is drawing increasing numbers of people to Montana to live or to vacation.

The ownership pattern of land within Montana's boundary is key to the recreational opportunities so highly valued by Montanans and visitors alike. Approximately 57.8% of the state's landscape is in private ownership, 7.2% in Tribal ownership and the remainder, 35%, in public ownership (MEQC 1996). Jurisdiction of lands in public ownership is as follows: U.S. Forest Service (USFS), 17.9%; Bureau of Land Management (BLM), 8.8%; state 5.6%; National Park Service (NPS), 1.3%; and "other federal," 1.4%.

Most surveys of recreational use in Montana have been keyed to trail-based recreation. A 1994 inventory of trails in Montana documented a total of 2,294 trails comprising a cumulative linear distance of more than 14,633 miles (Yuan et al. 1994). Ninety-two percent of trail miles are on USFS lands (primarily in the western half of the state), 6% of the total on NPS lands, and the remaining 2% falling under the jurisdiction of other federal and state agencies (see Table 1.1).

Table 1.1. Numbers of trails and total trail miles in Montana, by jurisdiction (Yuan et al. 1994).

AGENCY	# OF TRAILS	# OF MILES
FEDERAL		
U.S. Forest Service	2,075*	13,496*
National Park Service	148	826
Bureau of Land Management	9	167
U.S. Fish and Wildlife Service	6	5
Federal Subtotal	2,238	14,494
STATE OF MONTANA		
Montana FWP	15*	28*
University of Montana	6	21
Local government	28	60
Reservations	5	6
Commercial entities	2	24
State Subtotal	56	139
TOTAL	2,294	14,633

* In addition to the 28 miles of trails maintained on MFWP lands, the MFWP snowmobile program funds the grooming of more than 3,772 miles of snowmobile trails in the state (MFWP 1997).

Several recent surveys provide insight to the current status of trail-based recreation in Montana. A 1998 survey of Montana residents conducted by Montana FWP (MFWP 1998) found that 56% of respondents reported having used a trail in the state within the previous 2 years. The manner in which trails were used was reported as follows: 90% hiking, 11% horse riding, 6% bicycling, 4% cross-country skiing, 3% hunting, 2% 4WD, 2% ORV, 2% off-road motorcycle, 2% snowmobile, and 1% "other."

Other relevant findings of the 1998 survey (MFWP 1998) included:

- Twenty-six percent held a valid hunting license, and 32% said they had hunted in Montana within the past 2 years.
- Thirty-two percent held a valid fishing license, and 44% said they had fished in Montana during the past 2 years.
- Six percent held a valid state parks passport, and 31% said they had visited a state park within the past 2 years.
- Fifty percent of the respondents indicated that they had gone on a trip or outing of greater than 1 mile during the previous 2 years for the primary purpose of watching or photographing wildlife.
- Other forms of recreation reported by respondents were picnicking (78%), camping (56%), boating (39%), PWC (8%), and trapping (2%).

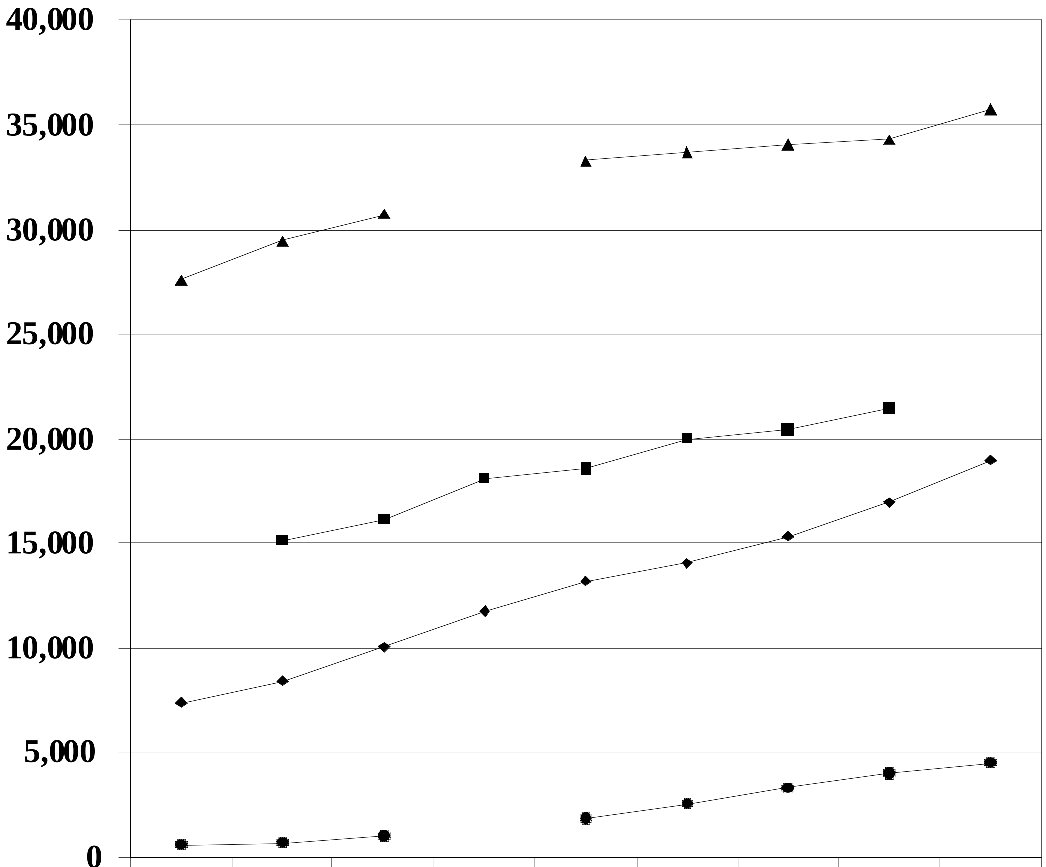
Results of a recreation study conducted by the Institute for Tourism and Recreation Research at University of Montana (McCool and Harris 1994) documented the following participation rates and average distance traveled for various recreational activities: walking/day hiking (70% / 2.5 mi), jogging (19% / 2.5 mi), bicycling (20% / 4 mi), off-road 4WD (20% / 31 mi), horse riding (17% / 10 mi), cross-country skiing (15% / 4.5 mi), snowmobiling (15% / 27 mi), backpacking (14% / 5 mi), mountain biking (14% / 6 mi), ORV riding (12% / 15 mi), off-road motorcycling (9% / 25 mi).

Reliable data on annual sales or use of most kinds of recreational equipment are not readily available. However, vehicle registration data for types of motorized recreational vehicles that require registration decals are available. Upward trends in registration of ORVs, snowmobiles, boats (>12 feet in length), and PWC (Figure 1.1) are indicative of upward trends in use of such vehicles and reflect a general upward trend in outdoor recreation participants. These figures are minimum numbers, as the registration decal requirement does not apply to equipment used only on private land.

Watercraft are registered according to type and length classes. Between 1990 and 1998, the total number of units registered increased from 36,744 to 49,119. The increase in the number of watercraft registered during the 9-year period was attributable primarily to PWC (+ 3,910), boats longer than 17 feet but shorter than 19 feet in length (+3,850) and boats 19 feet and longer (+3,235) (Figure 1.2). Percent increases in units registered between 1990 and 1998 for each of the various categories of watercraft include: canoes (+12.5%), pontoon boats (+96%), inflatables (+19.8%), PWC (+700%), boats <14 ft (-4.8%), boats >14 & <16 ft (-0.1%), boats >16 & < 17 ft (+17.4%), boats >17 & < 19 ft (+60%), and boats >19 ft (+95%).

TOURISM

The demand for personal travel virtually exploded after WWII and tourism is now the world's largest industry (Smith, no date). Due to its natural beauty, the easy access to public land, and array of recreational opportunities, Montana is a natural recreation destination for people from other states as well as other countries. A 1986 President's Commission on Americans Outdoors documented that natural beauty and amount of crowding are the 2 most important parameters considered by Americans when choosing places to recreate. A recent survey (The Lutz Research Companies 1999) found that 50% of Americans prefer outdoors-recreation destinations (21% beach or shoreline; 20% national parks and forests; and 9% lakes, rivers, and mountains). A 1997 survey of visitors to Montana (MFWP 1999) verified that tourists are drawn by Montana's natural features and identified the top 8 attractions that visitors cited as their reasons for visiting Montana as: mountains (51%), Yellowstone National Park (39%), rivers (36%), open space (32%), Glacier National Park (31%), viewing wildlife (28%), uncrowded areas (28%), and lakes (27%). The fact that Montana is viewed as the place where scenic, uncrowded recreational opportunities are abundant, when combined with continued population growth nationwide portends continued tourism growth in Montana.



	1990	91	92	93	94	95	96	97	98
OHV	7,399	8,404	10,020	11,729	13,165	14,072	15,352	16,898	18,953
Snowmobile		15,142	16,164	18,099	18,572	20,030	20,398	21,467	
Boats	27,562	29,451	30,764		33,300	33,726	34,075	34,256	35,738
PWC	560	723	1,031		1,914	2,559	3,289	3,968	4,470

OHV = off-highway vehicles - includes all-terrain vehicles (ATVs, 3 and 4 wheeled) and off-road motorcycles
PWC = personal watercraft (e.g., jetski, waverunner)

Figures tabulated by fiscal year for snowmobiles and by calendar year for ORVs, boats, and personal watercraft (PWC).

Figure 1.1. Number of units registered by year in Montana for recreation vehicles that require a registration decal (MFWP OHV annual report, MFWP snowmobile annual report, Montana Department of Justice, Title and Registration Bureau)

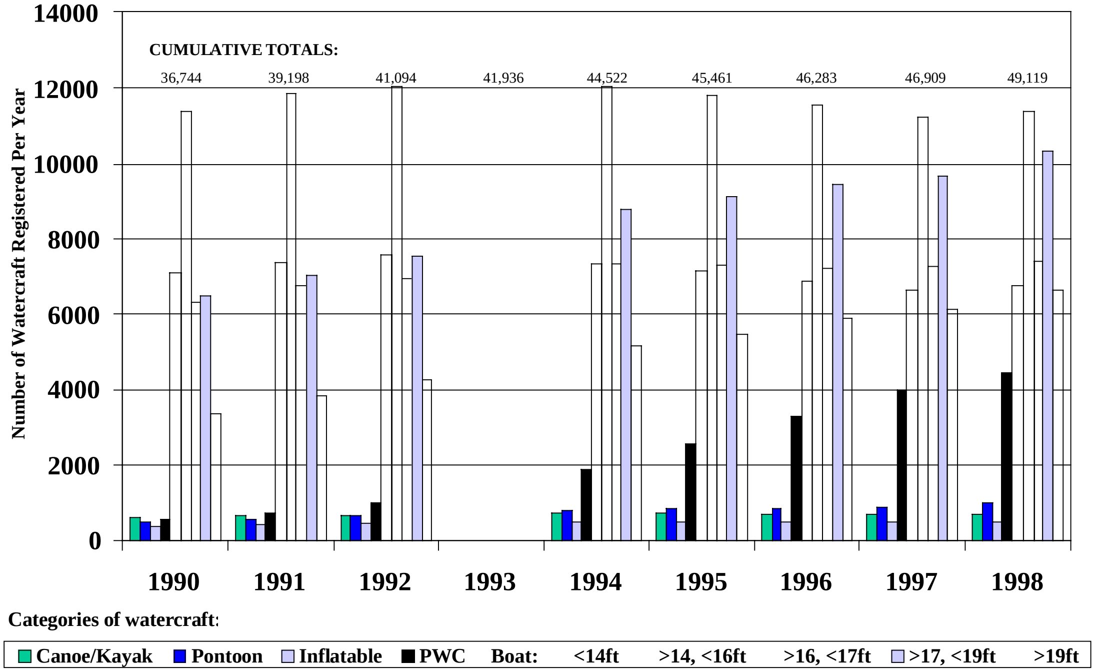


Figure 1.2. Number and type of watercraft registered annually.

Tourism is actively promoted by Travel Montana, a division of the Montana Department of Commerce, as an important element of the state's economic development. Travel Montana's 5-Year Marketing Plan (1998 - 2003) states "Travel and tourism in Montana is a growth industry - one of the keys to our state's economic development – and the impact is has on Montana is extraordinary" (Travel Montana 1998). The Travel Montana mission statement is:

> . . . to strengthen Montana's economy through the promotion of the state as a vacation destination and film location. By maximizing the combined talents and abilities of its staff, and with guidance from the Governor's Tourism Advisory Council, Travel Montana strives to promote a quality experience to visitors while encouraging preservation of Montana's environment and quality of life.

The goal of Travel Montana is to utilize accommodations tax monies in a cost-effective manner to promote the state's tourism industry. Of 5 priority tourism issues listed in Travel Montana's 5-year marketing plan, the first is:

> Development of sustainable tourism while maintaining quality of life and protecting natural, cultural and recreational resources.

Of 12 marketing objectives listed in Travel Montana's 5-year marketing plan, the first is to:

> Focus the promotion and development of Montana's travel industry on our natural, historical, cultural and recreational resources.

Recent tourism statistics compiled by the Institute for Tourism and Recreation Institute (Travel Montana 1998) include:

- Montana hosted 9.25 million visitors in 1998, an increase of 5% from the previous year and an increase of 25% since 1991.

- The 1998 average group size was 2.4 people for a total of 3.85 million groups.
- Between 1991 and 1998, nonresident visitor expenditures grew 23% from $1.24 billion to $1.52 billion.
- Visiting groups were classified as vacationers (49%); non-residents visiting family and friends (22%); business travelers (11%); visitors passing through (9%); and visitors who came to shop, attend conventions, obtain medical treatment and other reasons (9%).

BIOLOGICAL CONSIDERATIONS: WILDLIFE AND WILDLIFE HABITATS

A growing human population, transformation of recreational equipment with the advent of technological advances, and continued proliferation of new forms of recreation can be expected to expand human activity into wildlife habitats, including areas where direct human influences have previously been minor or entirely absent. In the face of recreational trends, the lack of information about wildlife communities and wildlife requirements and/or the poor planning of recreational development could render wildlife values vulnerable across entire landscapes.

The term "non-consumptive" is a misnomer when applied to recreational activities because hunting and non-hunting forms of recreation can potentially have the same end result, whether at the individual level or population or community level. Many activities can potentially displace wildlife, reduce productivity, and ultimately increase mortality (Knight and Cole 1995). Weeden (1976) dismissed the notion of nonconsumptive use of wildlife with examples of detrimental effects of nonconsumptive uses of wildlife. He concluded that there is no such thing as a nonconsumptive user, rather, there are consumers who care about wildlife and those who do not. Boyle and Samson (1985) reviewed 166 articles containing original data on the effects of nonconsumptive outdoor recreation on wildlife and found that in 81% of them, effects were considered negative.

A body of literature relevant to disturbance of wildlife emerged in the 1970s. However, many early references to the effects of recreation on wildlife were anecdotal rather than products of scientific inquiry. Fletcher and Busnel (1978) pointed out the shortcomings of research done to date, including: decibel scales used to assess wildlife response to noise were keyed to the narrow range of human hearing and, therefore, may not even be applicable to effects on wildlife; the need for research to address the effects of combined stressors; the need for research on the effects on various social groups; and study of long-term effects. Bury (1978) stated that due to the potentially vast combinations of environmental variables, it is difficult to generalize the results of virtually any study conducted on the direct impacts of snowmobiles on wildlife. Gutzwiller (1993) identified several impediments to reducing recreational impacts including: lack of a clear understanding of the cause-and-effect relationships; lack of information that relates the frequency, spatial scale, periodicity, or daily and seasonal timing of various recreational disturbances to wildlife variables; lack of knowledge about the impacts of pets; what the influence of party size is; how effects on individuals influence the age structure or persistence of populations; impacts on the structure and function of guilds and communities; and ripple effects through communities by way of interspecific interactions or cumulative impacts of simultaneous disturbances. McCool (1978) stated that research efforts have been non-cumulative, redundant, and noncomparable and have resulted in contradictory findings because of differing methodologies, definitions, and conceptual approaches used in isolated studies focused on local situations. He added that some studies did not conform to normal standards of scientific protocol (variables were not isolated or controlled). McCool (1978) pointed out the importance of understanding the behavior of recreationists and postulated that different types of behavior (competitive, play, exploratory, affiliation) have an important bearing on the type and intensity of impacts on wildlife. McReynolds and Radtke (1978) stated that experimental design of past studies has been poor, time span of testing too short to define effects, and the number of species investigated too small. Knight and Cole (1991) emphasized that well-designed studies are needed to understand how recreational activities affect the inclusive fitness of individuals, whether or how populations and communities are impacted, and whether or how ecosystems are impacted in turn. Authors and reviewers of this report selected and relied upon published information that meets commonly accepted standards for study design and data analysis.

Human activities can impact animals through 4 primary routes: exploitation, disturbance, habitat modification, and pollution (Knight and Cole 1995). Disturbance caused by recreational pursuits or other human activities may elicit behavioral responses and/or physiological responses in wildlife. Some behavioral responses are unique to certain species, such as the propensity of bighorn sheep and mountain goats to withdraw to cliffs when hearing sudden, loud noises. This behavior is assumed to be an innate response to rockfalls and avalanches (Geist 1971, 1978). The learned component of wildlife responses to humans has been attributed to the number and outcome of interactions between individuals and human stimuli during an individual's lifetime (Newton 1979, Poole 1981, Buitron 1983, Fraser 1984, Knight and Temple 1986) and may, therefore, vary among individuals or populations. An individual's behavioral response may also vary according to season, age and sex, body size, group size, motivational state, behavioral responses of cohorts, and habitat security (Knight and Cole 1995). For example, absence of overt behavioral responses by bighorn sheep and mountain goats during encounters with people may be a function of the relative security of the habitats they occupy.

Behavioral responses are influenced by characteristics of the disturbance itself (type of activity, distance away, direction of movement, speed, predictability, frequency, and magnitude) and location (above versus below, in the open versus screened by topography or vegetation) (Knight and Cole 1995). The most detrimental (energetically costly) disturbances to wintering animals are those that are unanticipated (MacArthur 1982, Parker et al. 1984). In circumstances where motorized use is predictable and localized (confined to routes), wildlife response to people afoot or skiing may be more pronounced than it is to motorized vehicles.

Wildlife behavior may take the form of avoidance, habituation, or attraction (Knight and Temple 1995).

Avoidance: An association with pain or punishment (as exhibited by behavioral shifts during hunting season). Avoidance behavior increases with an increasing number of negative encounters and may result in displacement and changes in distribution. Panic-type avoidance responses may occur as a result of any kind of abrupt, unexpected intrusion (Busnel 1978).

Habituation: A waning of response to a repeated stimulus that is not associated with either a positive or negative reward (Eibl-Eibesfeldt 1970). Habituation reduces the physiological cost of dealing with an environmental stress factor, but it seldom eliminates the cost entirely. Habituated animals may have chronically elevated heart rates (Cassier and Ables 1990). If visual and acoustical stimuli are predictable in space and time, the process of habituation by wildlife is enhanced (Geist 1978). Habituated individuals may go so far as to seek centers of human activity to forage or to avoid predators, as in cases of habituated deer, elk and other wildlife in residential settings. Habituation may culminate in an array of challenges for the wildlife manager (Thompson and Henderson 1998). Conflicts with humans resulting from habituation may ultimately result in mortality (e.g., vulnerability to hunters or poachers, vehicle collisions, management removal in response to chronic property damage).

Attraction: Strengthening of an animal's behavior as a result of rewards. Some species seek food sources they associate with humans (garbage, pet food, and bird feeders in the case of bears) and others go so far as to approach humans for food (e.g., chipmunks, jays). Mountain goats are known to approach people as a source of salt.

Behavioral responses may be of short duration (temporary displacement) or long-term, such as abandonment of preferred foraging areas (Geist 1978). Likewise, physiological responses that affect an individual's energy budget may result in death. At the population level, physiological responses may result in reduced productivity (Yarmoloy et al. 1988).

Physiological responses to disturbance cannot be assumed to be observable. Reliance on overt behavior as an indicator of stress can be misleading (Stemp 1983). In addition to the shortcomings of behavior as a stress indicator, association of behavioral cues with physiological stress varies among species. For example, stress responses of moose *(Alces alces)* are subtler than for other ungulates (Shank 1979).

Most people understand that obvious behavioral responses, such as flight or interference with foraging, have energetic costs and can thereby reduce vigor. However, many people have no idea that subtle physiological responses, such as an elevated heart rate (MacArthur et al. 1982) and changes in alertness and posture, have energetic costs as well. Most people are familiar with the energetically costly active-defense response (fight-or-flight) which is characterized by adrenalin-induced increases in heart rate, blood flow to skeletal muscle, increased body temperature, and elevated blood sugar (Gabrielsen and Smith 1995). However, an animal experiencing a deficit energy budget may employ an alternative behavioral and physiological response to disturbance that is expressed as the opposite of the active-defense response. The passive-defense response is characterized by the inhibition of activity, reduced blood flow to skeletal muscle, reduced blood flow to the digestive system, reduced heart and respiratory rate and reduction in body temperature (Gabrielsen and Smith 1995). The often-misinterpreted passive-defense response is documented in a wide variety of vertebrates and is especially well developed in newborn animals and incubating birds. Often misconstrued, as lack of response, habituation, or even "tameness," such behavior may be indicative of an animal experiencing a severe nutritional or energetic deficit or a set of circumstances that offers no escape option.

Specific effects of recreational activities on wildlife presented by Knight and Cole (1995) include:

Hunting: Alteration of sex and age composition, behavior, reproduction (date of conception in elk in Colorado, Squibb et al. 1986), and distribution.

Viewing: Disturbance as a result of close encounters may alter behavior, cause unnecessary energy expenditure, alter nest placement, and reduce survivorship of young (via abandonment or predation).

Backpacking/Hiking/Cross-country skiing/Horseback Riding: Flight and/or elevated heart rates, displacement.

Rock Climbing: Disturbance of preferred raptor perching and nesting sites during the breeding season, displacement.

Spelunking: Disturbance or abandonment of bat roosting and maternity sites. Spelunking is implicated in the decline of bat populations.

Pets (dogs): Provoke more of a predator-alarm response than a person unaccompanied by a dog, harassment/energy expenditure, direct mortality.

Boating/Personal Watercraft: Can deprive waterfowl, wading birds, and raptors of roosting or foraging habitats; flushing of birds from nests may result in egg breakage; changes to riparian vegetation, bank stability, and water quality can affect semi-aquatic mammals, and there can be a release of toxic by-products from combustion into the water.

OHVs (motorcycles, ATVs, quadricycles, dune buggies, amphibious vehicles, and air-cushion vehicles): May cause disturbance (flight and/or stress) and redistribution.

Snowmobiles: May cause disturbance (flight and/or stress) –and/or redistribution, and there can be a release of toxic by-products from combustion into snowpack and water.

Aircraft: May cause disturbance, including panic flights, that may result in abandonment or loss of young.

Effects of disturbance (behavioral and physiological responses) may have ramifications to populations. For example, disturbance that alters behaviors within a local population, which then results in distribution and habitat use changes, may ultimately alter reproductive success and, therefore, the health and status of the population.

Pollution is associated with use of motorized vehicles that discharge products of combustion into air, soil, and snow, from where these pollutants will make their way into streams, rivers, and lakes. In the case of marine engines, including PWC, products of combustion are discharged directly into the water. As much as 30% of the fuel used by two-stroke outboard and PWC engines is discharged unburned into the water (California Environmental Protection Agency 1999). At this rate, an average two-hour ride on a PWC may discharge 3 gallons of the gas/oil mixture into the water (NPS 1999). The impacts of discharged oil and gasoline from boat motors on aquatic organisims are, as yet, poorly understood (Cole and Landres 1995). Pollution is also an issue with respect to garbage and human excrement.

A collective understanding of how recreational activities influence communities is developing (Gutzwiller 1995). Keystone species provide the most graphic scenarios of how effects on one species or population can alter interrelationships and processes within a community. Keystone species are species whose roles within a community are especially pronounced. Roles that confer "keystone" status include the role of being an important prey base (snowshoe hare, *Lepus americanus*), predator (wolf, *Canis lupus*), or creator of habitat conditions required by other species (prairie dog, *Cynomys* spp. or beaver, *Castor canadensis*).

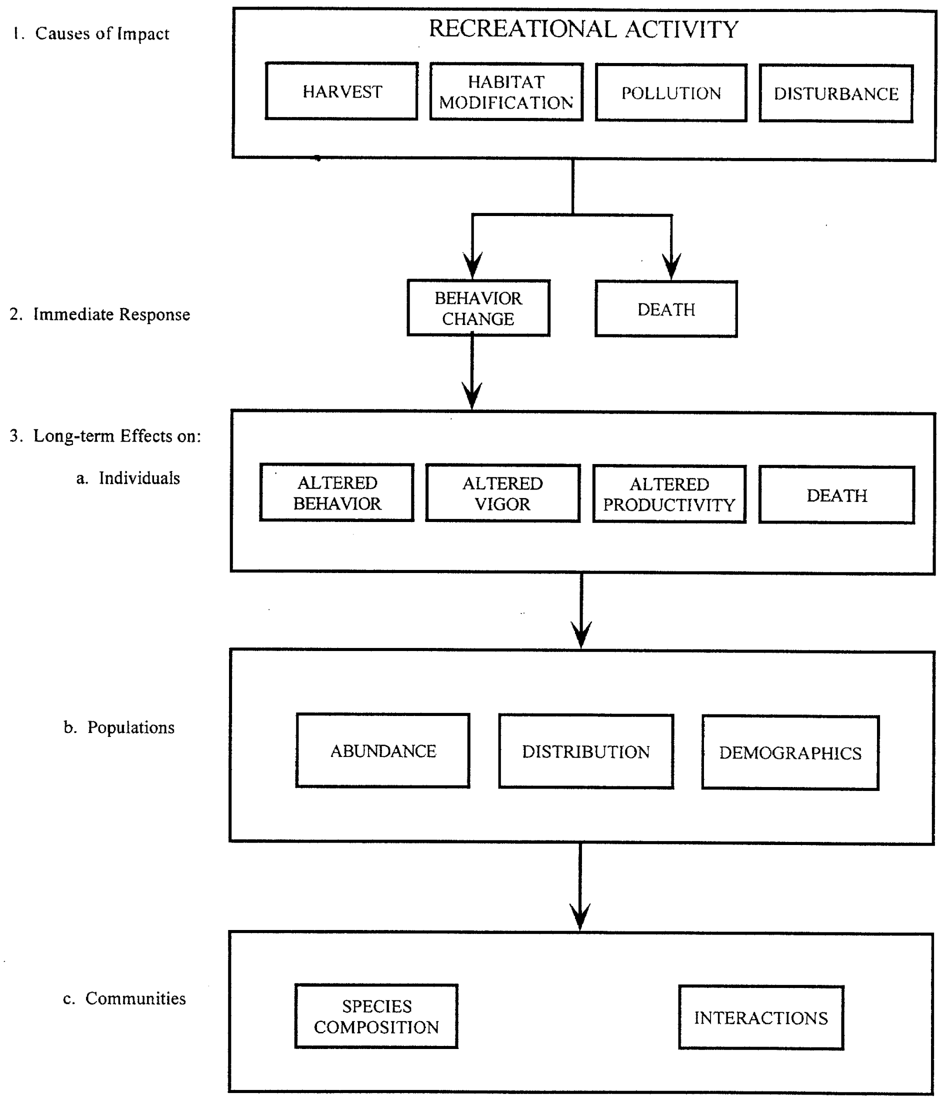


Figure 1.3. A conceptual model of responses of wildlife to recreational activities (Knight and Cole 1995, *in* Knight and Gutzwiller, eds. 1995. *Wildlife and Recreationists: coexistence through management and research*).

Knight and Cole (1995) proposed a conceptual model of hierarchical wildlife responses to potential effects of recreational activity (Figure 1.3). Effects of recreation on wildlife habitat and, in turn, on wildlife can be, in large part, unintended and incremental. However, unintended and incremental effects cannot be assumed to be unpredictable. The most obvious impact of human activity on the land is to the soil surface itself. Effects on soils, in turn, determine the presence (or absence) and the characteristics of vegetation supported (species composition, vigor, productivity, and structure).

Composition and structure of vegetation, in turn, determine the suitability of the site to serve as habitat for wildlife species closely tied to vegetative composition and/or structure. Habitat suitability for small mammal or amphibian species, for example, determines whether the habitat or landscape unit can support larger, more visible species, including predators.

The complex interrelationships within populations and communities demand a systematic approach to incorporating wildlife considerations into project analysis and planning. A systematic approach requires a hierarchical procession from soil to vegetation to individual species to populations to communities while encompassing the expanding breadth of interrelationships at each level. This iterative process progresses to ecosystems and ultimately to the biodiversity of a landscape or region. Likewise, a systematic approach to project monitoring is required to detect insidious, incremental changes in an ecological chain of events that would otherwise go unnoticed until a point at which cumulative effects culminate in changes that become obvious.

Species that tend to capitalize on food and shelter associated with humans are considered concomitants (e.g., raccoon, skunk, coyote, red fox, gulls, crows, gulls, starlings, cowbirds and English sparrows). Concomitant species are habitat generalists that exploit food sources and habitats associated with human activity and habitation, and, they may also capitalize on the absence of larger predators in areas occupied by humans (a result of removal or displacement). Habitat fragmentation tends to favor generalist, concomitant species over habitat specialists. Entry of concomitant species into communities and ecosystems as a result of habitat fragmentation, conversion of "interior habitats" to "edge habitats" and/or presence of human refuse that serves as a food resource may alter community composition as a result of competition for food, habitats (nest or den sites), and/or changes in predation and productivity rates.

INFORMATION, EDUCATION, AND ETHICS

If untempered by consideration for resource values, the recreational pursuits of a single person can result in detrimental effects to natural resources, including wildlife. Information and education programs can serve the purpose of fostering conduct that is compatible with wildlife values. As an increasing human population exerts pressure on wildlife populations inhabiting a shrinking land base, it is crucial that a prevailing utilitarian view of public lands as "here to be used" in individual recreational pursuits be replaced by attitudes and management that foster use and enjoyment of the environment in a caring manner that is sustainable, particularly with respect to wildlife resources.

There are a number of levels at which information and educational materials can be focused:

> **Acceptance/tolerance**: Dispel mythology and misconceptions about wildlife species that humans have traditionally feared (e.g., wolves, mountain lions, grizzly bears, bats, snakes), viewed as competitors with wildlife, fish, or domestic livestock (e.g., eagles, prairie dogs, pelicans), or viewed as a nuisance (e.g., colonial nesting birds perceived as messy). Acceptance and tolerance would be fostered by replacing fear and mythology with facts, providing information on how to avoid conflicts, and discouraging misguided killing of particular wildlife species or destruction of their habitats.
>
> **Awareness**: Inform people of nature-viewing opportunites, wildlife species inhabiting the area, wildlife identification, where and when to view wildlife, and appropriate nature-viewing conduct.
>
> **Education/Appreciation**: Convey information about life history and habitat requirements of various wildlife species and their roles in ecosystems; the dynamics of wildlife populations, communities and ecosystems; conservation of wildlife resources; and potential ramifications of inappropriate recreational conduct on wildlife and wildlife habitats.
>
> **Wildlife/Land Ethic**: Instill a sense of compassion for wildlife and a personal obligation with respect to practicing land and wildlife stewardship and encouraging others to do so.

Aldo Leopold's "land ethic" is the best known environmental ethic of our time (Oelschlaeger 1995):

> A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise. ~~ Aldo Leopold 1949 ~~

Oelschlaeger (1995) proposed that "recreation, recontextualized through the land ethic, leads to something quite different than a 'recreational ethic,' which advises recreationists to travel lightly upon, avoid harm to, and leave no trace of human presence in the environment." He stated that the difference is that "the land ethic encourages humans to behave as members of the 'land community' rather than as rational agents who have found reasons to treat the environment prudentially." He also asserted that if the land ethic were to be culturally institutionalized, then "recreation would be more akin to going to church than an escape from daily routines."

Oelschlaeger (1995) asserts that "the land ethic approach to management is a path not taken by the majority of our resource managers," instead, management programs that resource managers deliver are "designed to meet the needs and demands of a public hungry for outdoor recreation following World War II . . . in short, model utilitarian procedures."
After spending the better part of two years researching potential effects of recreation on wildlife habitat, members of the Montana Chapter, TWS believe that introspection on the part of resource managers with respect to where our practices and programs fall on the utilitarian – holistic/sustainable spectrum is well advised. In looking toward the future, we would also be well advised to reassess our role as professionals in fostering wildlife acceptance, awareness, education, and appreciation as well as developing a wildlife/land ethic within our professions and among the recreating public.

GENERAL GUIDELINES

The ultimate goal of the Committee on Recreation in Wildlife Habitat is to synthesize all available information and to propose guidelines and recommendations that are supported by published literature. This was most easily accomplished in the case of species or species groups for which there is a significant amount of published literature addressing agents of disturbance. In the case of other species/species groups (i.e., beaver, forest carnivores, and owls), published information related to disturbance is limited or non-existent. In these cases, chapter authors have presented recommendations that are based on a synthesis of life history and habitat requirements as well as drawing upon their professional judgement and experience. Recommendations listed here present an adaptive management opportunity that can both protect wildlife values while validating recommendations through monitoring or research.

The biological factors to which guidelines are keyed vary according to species group. In the case of small mammals, guidelines are keyed to the habitat requirements of species formally designated "of special concern" and several special habitat types deemed fragile. In the case of ungulates, guidelines are keyed to life stages that are critical to energetic and reproductive requirements (seasons). Guidelines are not presented for generalist species considered concomitants (coyotes, fox, raccoon, skunk, crows, gulls, house sparrows, starlings, cowbirds, and skunks) or for species for which little or no published literature exists regarding the influence of disturbance agents. In the case of concomitants, human presence and activities are likely to increase their numbers and their distribution, which may result in changes in community composition. Secondary effects of expanded numbers and distribution of concomitant species may occur at the community level, such as interspecific competition for food or nest sites, or increased predation. In the case of species for which only life history information exists, the manager is encouraged to exercise professional judgement and knowledge of life history to predict consequences of proposed actions.

At the broad, general level, guidelines from species chapters can be summarized according to planning and management categories as follows:

PLANNING

1. Protect soil, air, and water from degradation.
   - Identify geographic areas with soil types and topography vulnerable to damage by recreational activities (e.g., highly erosive soils, steep slopes).
   - Avoid accelerated erosion/increased sedimentation rates by directing soil-disturbing activities away from fragile soil types, fragile plant communities, and other sites most vulnerable to disturbance.
   - Avoid locating recreational activities in areas with soils contaminated by mine tailings.
2. Protect species composition and structure of vegetation communities.
   - Identify vegetation communities (including those considered fragile and unique).
   - Maintain vegetative communities and features required by wildlife (e.g., whitebark pine stands for grizzly bears, snags for cavity nesters, downfall for medium-sized forest carnivores).
3. Maintain natural ecological processes, including hydrological processes, hydroperiod and natural water level fluctuations and presence of various successional plant communities.
4. Identify sensitive species, sensitive habitats/communities, and keystone species (which by virtue of their role in a community exert a disproportionate influence on community structure, composition, and dynamics) (e.g., beaver, prairie dogs).

5. In the event that information is lacking for species or populations in the landscape, the project should be planned and implemented in a manner that considers the most energetically demanding life stages (i.e., females with dependent young) and/or life stages with special behavioral considerations (e.g., breeding, over-wintering).

6. Identify and protect areas required by wildlife during sensitive life stages by locating recreational sites and travel corridors to avoid:
   - Ungulate wintering areas, including creating snow-packed routes leading to or near wintering areas that may be used by predators to access wintering ungulate populations otherwise inaccessible due to snow depths;
   - Areas used for birthing and the immediate postnatal period (some mammal species);
   - Breeding period (some bird species);
   - Seasonal migration corridors and movement corridors between foraging and resting areas;
   - Key foraging areas;
   - Formally designated and *ad hoc* refugia (for forest carnivores) important to sustaining populations across landscapes via dispersal of subadults and sanctuary areas required for successful breeding or rearing of young (e.g., loons, other bird species).
7. Assess land ownership patterns so that recreational sites and travel routes are located in areas that will not promote redistribution of ungulates from public land to private lands (where they may cause conflicts with landowners).
8. Locate recreational sites and travel routes in a manner that capitalizes on use of natural features (topography and vegetative cover) to provide visual and acoustic barriers to activities and associated noise that cause disturbance/stress to potentially affected wildlife populations.
   - Provide for screening vegetation for nest sites.
9. Identify past and pending wildlife enhancement/protection projects to ensure that the proposed recreational activities would not negate wildlife benefits intended by those projects (e.g., establishment of a hiking trail through a shrubfield enhancement project that was designed to improve bear/moose habitat).

Planning guidance is presented in Appendix C.

MANAGEMENT

1. Avoid degradation of soil, and air, and water quality.
   - Avoid/minimize discharge of pollutants/toxins into air and water (including snowpack).
   - Minimize introduction of substances that may inadvertently become environmental contaminants off-site (e.g., road treatment substances, by-products of combustion [oil, gas], heavy metals, nitrates).
   - Locate roads, trails, picnic areas, campgrounds and other developments away from riparian and shoreline habitats.
   - Direct/confine activities that result in compaction and/or erosion of soil to sites and travel routes where they will cause the least damage.
   - Direct/confine activities that create soil disturbances to avoid the introduction and establishment of noxious weeds.
   - Precautions should be taken to avoid secondary effects when applying herbicides and pesticides to achieve management objectives for vegetation. Select herbicides and pesticides that decompose rapidly and avoid using them in proximity to water bodies or wetlands.
2. Maintain integrity (species composition, structure, vigor) of vegetation communities.
   - Direct/confine activities that damage/destroy vegetative cover and thereby create conditions conducive to establishment of weeds.
   - Maintain vegetation/community structure (including sustained yield of snags suitable for cavity nesting birds and downfall required by forest carnivores).
3. Manage human activity (spatial and temporal) to minimize disturbance of habitats/sites required by wildlife at sensitive life stages and that are of limited occurrence and/or prone to damage.
   - Make use of designated travel corridors and "play areas" within area closures to confer predictability to wildlife disturbances (location, direction, speed, and timing of activities).
   - Establish viewing sites that provide viewing opportunities and reasonable approach distances that will not provoke behavioral or physiological stress responses.

- Locate facilities and travel routes to avoid introducing human activity to sensitive habitat features (e.g., bogs, caves or abandoned mine features that may serve as bat nurseries or hibernacula, amphibian breeding areas, wolverine denning habitat, sensitive wetland communities).
- Apply buffer zones to human activity (refer to species chapters) in the vicinity of nest sites; lek sites; important breeding, roosting, and foraging sites; and migration-staging areas (birds). Buffer zones may also apply to certain activities that produce noise that would cause stress/disturbance (e.g., discharge of firearms, motorboats, and personal watercraft). *Refer to management recommendations for loon nest sites.
- Apply seasonal use restrictions or closures where needed to minimize or prevent disturbance/displacement (e.g., stream stretches critical for harlequin duck breeding and rearing).
- Apply temporal management of recreational activity by calendar day/hour where warranted to minimize disturbance/displacement (e.g., prohibit nighttime use of a ski trail in close proximity to an ungulate winter range).

4. Develop management precautions to prevent detrimental changes to community interrelationships.
   - Locate recreational facilities or travel corridors in a manner that minimizes habitat fragmentation. (Habitat fragmentation may increase the success of generalist species associated with "edges" while reducing the relative success of specialized species that are dependent on "interior"/later successional vegetative communities. For smaller species [small mammals, herpetiles] habitat fragmentation can interfere with or preclude seasonal migration and/or dispersal.)
   - Minimize the potential for introduction of non-indigenous species and/or pathogens that could compete or hybridize with, prey on, or infect native species.
   - Locate development projects and travel corridors in a manner that minimizes entry of competitors, predators, and nest parasites to habitats where they previously did not exist.
   - Minimize entry or the potential for increasing the abundance and influence of concomitant species in communities where they previously did not exist.
   - Manage human refuse (human excrement, garbage) and discourage feeding of wildlife. Inadvertently providing wildlife with food rewards may lead to habituation or confer competitive advantages (artificial food sources, shorter flushing distance at food sources) to concomitant species.
5. Replace single-species management approaches with community approaches.
   - Wildlife values should be considered prior to removal of beaver dams to achieve fish management objectives.
   - Habitat requirements of amphibians should be considered in management of waterfowl production areas.
   - Precautions should be taken to avoid secondary effects when applying piscicides to achieve management objectives for fish populations. If used, piscicide application should be preceded by an inventory of amphibians present and application should be timed (season and time of day) to minimize impacts to adult amphibians.
6. Consider indirect effects of increased human access (> road/trail density) to areas/landscapes including mortality factors such as hunting/trapping harvest rates, poaching, and vehicle collisions.
   - Maintain habitat security during hunting and trapping seasons via management of vegetative cover and structure and access management.
   - Minimize vehicle collisions resulting from recreationist traffic (sign crossing zones, post speed limits, and breach snowplow berms to provide escape routes from roadways, to coincide with traditional travel routes).
   - Manage road kills in a manner that minimizes the potential for vehicle collisions and other wildlife/human conflicts.
7. Develop management actions to minimize the effects of the presence of companion dogs on wildlife in critical habitats and during critical life phases.
   - Prohibit dogs on winter ranges during the winter season.
   - Consider prohibiting dogs on ungulate winter ranges and calving/fawning areas during the early and late spring periods.
   - Require dogs to be under voice or leash control around campgrounds and on trails.
   - Require leashes in sensitive habitats and/or during sensitive life stage periods.
8. Manage spatial and temporal components of aerial recreational activity to minimize disturbance and stress to wildlife.
   - Establish predictable flight routes that provide an adequate buffer for ungulate wintering areas, raptor nest sites, wolverine denning habitat, and other sensitive situations.
   - Establish minimum flight altitude.

  - Protect other recreationists and wildlife by locating operations such as heli-skiing in areas with low avalanche potential, where there is no need to use explosives to trigger avalanches to accommodate skiing.
9. Manage water-based recreation to minimize disturbance of semi-aquatic wildlife species, damage to riparian vegetation and damage to the structure and stability of banks.
   - Establish limits on use and speeds of boats and PWC according to the size, hydrology and ecological characteristics of water bodies (direct high-speed activities away from small, shallow water bodies prone to turbidity, to large lakes and reservoirs).
   - Direct shoreline activities to designated areas of lower quality riparian/shoreline habitat.
   - For selected water bodies, establish no-wake or reduced speed operation zones within shoreline buffer strips (to allow wakes to dissipate before reaching shore, to minimize bank erosion/failure).
10. Identify wildlife concerns associated with the affected environment for the project that warrant special information and education efforts.
    - Inform the public of the importance and sensitivity of certain habitat features, wildlife life stages, or communities (e.g., bat hibernacula, species and characteristics of snag trees preferred by cavity nesters).
    - Consider developing guidelines for woodcutters (e.g., take downed material only and how to identify and avoid taking snags most preferred [species, size, structure] by cavity nesting birds).
    - Communicate ways to enjoy and value wildlife "in the wild" (non-threatening approaches, appropriate approach distances, negative consequences of feeding wildlife).
    - Inform landowners who have a stake in protecting wildlife and wildlife habitat on private lands.
    - Inform the public of the negative consequences of introducing non-indigenous species into aquatic and terrestrial communities.
    - Inform the public how to avoid as well as how to respond appropriately to encounters with black and grizzly bears, moose with young, lions, rattlesnakes, and other potentially threatening confrontations with wildlife.
    - Inform the public about potential effects of recreational activities and recreationist conduct on wildlife – including unsupervised dogs.
    - Inform the public of conduct appropriate to co-exist with/maintain wildlife values.
    - Dispel myths to discourage persecution of species based on perceptions that they are dangerous (snakes, bats) or disease vectors (bats, colonial nesting birds).
    - Inform the public of potential impacts associated with water-based recreation (impacts of high speeds/boat wakes close to shore, pollution associated with different types of boat engines, and importance of tuning and maintaining engines to minimize pollution).
11. Develop and deliver information and educational materials in a manner designed to reach known and potential users.
12. Provide a mechanism for adaptive management, which may be defined as a feedback loop that facilitates learning from the experience of managing and monitoring projects/programs and adjust projects/programs to achieve management objectives. Adaptive management is predicated on:
    - Monitoring effectiveness of ecological dynamics and management strategies;
    - Keeping up-to-date with recent research findings;
    - Anticipating changing conditions within the ecological community as well as changes in types of use and numbers of participants;
    - Adjusting management strategies and organizational behavior based on new information.

Refer to species chapters for more detailed guidelines and recommendations specific to species groups.

LITERATURE CITED

Blackburn, J., and M. B. Davis. 1994. Off-road vehicles: function and/or folly. ASPI Publications, P.O. Box 298, Livingston, KY.

Boyle, S. A., and F. B. Samson. 1985. Effects of nonconsumptive recreation on wildlife: a review. Wildlife Society Bulletin 13:110-116.

Buitron, D. 1983. Variability in the responses of black-billed magpies to natural predators. Behavior 78:209-236.

Bury, R. L. 1978. Impacts of snowmobiles on wildlife. Transactions North American Wildlife Conference 43:149-156.

Busnel, R. G. 1978. Effects of noise on wildlife: introduction. Pages 7-22 *in* Fletcher and Busnel, eds. Effects of noise on wildlife. Academic Press, Inc.

California Environmental Protection Agency. 1999. Air Resources Board fact sheet – New regulations for gasoline engines. www.arb.ca.gov/msprog/marine/marine.htm

Cassier, E. F., and E. D. Ables. 1990. Effects of disturbance by cross-country skiers on elk in northern Yellowstone National Park. Final report to the National Park Service. 103pp.

Cole, D. N., and P. B. Landres. 1995. Indirect effects of recreationists on wildlife. Pages 183-202 *in* Knight and Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C. 372pp.

Cordell, K. H., J. Teasley, and G. Super. 1997. Outdoor recreation in the United States: results from the national survey on recreation and the environment, Rocky Mountain Region. Outdoor recreation and wilderness assessment group, U.S. Forest Service, Athens, Georgia, and Department of Agriculture and Applied Economics, University of Georgia.

Eibl-Eibesfeldt, I. 1970. Ethology: the biology of behavior. Holt, Rinehart, and Winston, New York, N.Y. 530pp.

Flather, C. H., and H. K. Cordell. 1995. Outdoor recreation: historical and anticipated trends. Pages 3-16 *in* Knight and Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C. 372pp.

Fletcher, J. L., and R. G. Busnel, eds. 1978. Effects of noise on wildlife. Academic Press Inc.

Fraser, J. D. 1984. The impact of human activities on bald eagle populations – a review. Pages 68-94 *in*: J.M. Gerard and T.M. Ingram, eds. The bald eagle in Canada, proceedings of bald eagle days. Winnipeg, Canada.

Gabrielsen, G. W., and E. N. Smith. 1995. Physiological responses of wildlife to disturbance. Pages 95-107 *in* Knight and Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C. 372pp.

Geist, V. 1971. Mountain sheep: a study in behavior and evolution. University of Chicago Press, Chicago, Illinois. 383pp.

Geist, V. 1978. Behavior. Pages 283-296 *in* J. L. Schmidt, and D. L. Gilbert, eds. Big game of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania. 494pp.

General Accounting Office (GAO). 1995. Federal Lands: Information on the use and impact of off-highway vehicles. Report to the Honorable Bruce F. Vento, House of Representatives GAO/RCED-95-209. U.S. General Accounting Office, Washington, D.C. 20548.

Gutzwiller, K. J. 1993. Serial management experiments: an adaptive approach to reduce recreational impacts on wildlife. North American Wildlife and Natural Resources Conference 58:528-536.

Knight, R. L., and D. N. Cole. 1991. Effects of recreational activity on wildlife in wildlands. North American Wildlife and Natural Resources Conference 56:238-247.

Gutzwiller, K. J. 1995. Recreational disturbance and wildlife communities. Pages 169-181 *in* Knight and Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C. 372pp.

Knight, R. L., and D. N. Cole. 1995. Wildlife responses to recreationists. Pages 51-69 *in* Knight and Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C. 372pp.

Knight, R. L., and K. J. Gutzwiller, eds. 1995. Wildlife and recreationists: coexistence through management and research. Island Press, Washington D.C. 372 pp.

Knight, R. L., and S. A. Temple. 1986. Methodological problems in studies of avian nest defense. Animal Behavior 34:561-566.

Knight, R. L., and S. A. Temple. 1995. Origin of wildlife responses to recreationists. Pages 81-91 *in* Knight and Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C. 372pp.

MacArthur, R. A., V. Geist, and R. H. Johnson. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. Journal of Wildlife Management 46:351-358.

McCool, S. (1978). Snowmobiles, animals and man: interactions and management issues. North American Wildlife and Natural Resources Conference 43:140-148.

McCool, S., and J. Harris. 1994. The Montana Trail Users Study. Research Report 35. Institute for Tourism and Recreation Resesarch, The University of Montana, Missoula, Montana. 32pp.

McReynolds, H. E., and R. E. Radke. 1978. The impact of the motorized human 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 University, West Lafayette, Indiana.

Montana Environmental Quality Council (MEQC). 1996. Our Montana environment: where do we stand? Helena, Montana.

Montana Fish, Wildlife & Parks (MFWP). 1997. Snowmobile program annual report: July 1996-June 30, 1997. Parks Division, 1420 E. 6th Ave., Helena, Montana.

Montana Fish, Wildlife & Parks. 1998. Montanans' assessment of Montana fish, wildlife and parks programs: a report on the outcomes assessment project. Phase I: resident study. Helena, Montana. 62pp.

Montana Fish, Wildlife & Parks. 1999. Montana State Trails Plan (draft). Montana FWP, Helena, MT

National Park Service (NPS). 1999. Water quality concerns related to personal watercraft usage. Draft internal literature review. Water Resources Division, National Park Service, Fort Collins, Colorado. 11pp.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, South Dakota. 399pp.

Oelschlaeger, M. 1995. Taking the land ethic outdoors: its implications for recreation. Pages 335-350 *in* Knight and Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C. 372pp.

Parker, K. L., C. T. Robbins, and T. A. Hanley. 1984. Energy expenditures for locomotion by mule deer and elk. Journal Wildlife Management 48:474-488.

Poole, A. 1981. The effects of human disturbance on osprey reproductive success. Colonial Waterbirds 4:20-27.

Shank, C. C. 1979. Human related behavioral disturbance to northern large mammals: a bibliography and review. Report prepared for Foothills Pipe Lines (South Yukon), Ltd, Calgary.

Smith, S. L. J. No date. Tourism: the unknown giant. Department of Recreation and Leisure Studies, University of Waterloo, Waterloo, Ontario, Canada. www.eas.ualberta.ca/elj/als/alswp9.html

Squibb, R. C., J. F. Kimball Jr., and D. R. Anderson. 1986. Bimodal distribution of estimated conception dates in Rocky Mountain elk. Journal Wildlife Management 50:118-122.

Stemp, R. E. 1983. Heart rate responses of bighorn sheep to environmental factors and harassment. M.S. Thesis, University of Calgary, Alberta. 314pp.

The Luntz Research Companies. 1999. American Views on Land & Water Conservation – Summer, 1999. 1000 Wilson Boulevard Suite 950, Arlington, VA 22209.

Thompson, M. J. and R. E. Henderson. 1998. Elk habituation as a credibility challenge for wildlife professionals. Wildlife Society Bulletin 26(3): 477-483.

Travel Montana. 1998. 5-year marketing plan: July 1998 through June 2003. Department of Commerce, Helena, Montana. 10pp.

U.S. Census Bureau. 1999. http://www.census.gov/population/estimates/state

Weeden, R. 1976. Nonconsumptive users: a myth. Alaska Conservation Review 17(3): 3,15.

Yarmoloy, C., M. Bayer, and V. Geist. 1988. Behavior responses and reproduction of mule deer, *Odocoileus hemionus*, does following experimental harassment with an all-terrain vehicle. Canadian Field-Naturalist 10:425-429.

Yuan, S., M. Yuan, and J. Covault. 1994. 1994 Montana statewide trails inventory. Research Report 37. Institute for Tourism and Recreation Research, The University of Montana, Missoula. 69pp.

CHAPTER 2

AMPHIBIANS & REPTILES

EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE
A Review for Montana

www.montanatws.org

MONTANA CHAPTER OF THE WILDLIFE SOCIETY

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ABSTRACT

Through their interactions with other organisms, amphibians and reptiles are key components of many ecological systems. Consistent with the overall decline in biodiversity, amphibian and reptile populations have recently, or are currently, experiencing declines worldwide and in Montana. Direct and indirect impacts from human recreational activities may contribute to these declines. Although recreational impacts on Montana's herpetofauna have been little studied, the scientific literature provides several examples of factors often associated with recreation that do affect amphibian and reptile populations. Nonindigenous species can directly affect herpetofauna via competition and predation, and can indirectly affect herpetofauna through their management. For example, introduced fishes and bullfrogs may prey on or out compete native amphibians and reptiles and piscicides, herbicides, and pesticides used to control nonindigenous species are known to negatively impact populations of herpetofauna. Road traffic and off road vehicle use directly kill herpetofauna and indirectly impact populations by creating migration barriers, destroying habitats, and increasing sedimentation and chemical contamination. The development of recreational facilities and water impoundments may result in the loss of key breeding, foraging, and overwintering habitats for herpetofauna. Harvesting and collecting can have extremely negative impacts on herpetofauna populations and the general loss of habitat may lead to fragmentation and disruption of metapopulation dynamics. The relatively poor knowledge we have of the distribution, biology, and status of many of Montana's herpetofauna highlights the need to undertake thorough inventories of our public lands. Furthermore, the lack of knowledge of the distribution and status of many of these species makes it all the more important to properly manage recreational and travel activities that may negatively impact them.

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INTRODUCTION

Importance

Montana's 13 native amphibians and 17 native reptiles represent a valuable biological and cultural resource whose conservation is essential not only to their own survival, but to the survival of other vertebrate and invertebrate taxa as well. As larvae, amphibians structure aquatic communities by being important herbivores (e.g., Dickman 1968 and Seale 1980), competitors (e.g., Werner 1992), predators (e.g., Morin 1983 and Wilbur et al. 1983), and prey (e.g., Wilbur 1997). Many reptiles and metamorphosing amphibians act as key links between aquatic and terrestrial food webs as they transfer energy from aquatic prey to terrestrial predators (Wilbur 1997). The importance of adult amphibians and reptiles in terrestrial food webs is highlighted by their efficiency at converting the prey they consume to new animal tissue; as ectotherms they are more than 25 times more efficient than mammals or birds (Pough 1980, 1983). Their importance to terrestrial food webs is further highlighted by studies conducted in eastern deciduous forests and western deserts which demonstrate that amphibians and reptiles in those respective communities rival or exceed mammals and birds with respect to numbers, biomass, and energetics (Burton and Likens 1975*a*, Burton and Likens 1975*b,* and Turner et al. 1976).

Amphibians and reptiles also contribute a great deal to human welfare. In many impoverished societies they are among the most important sources of animal protein and many affluent societies import large quantities of frog legs for culinary purposes; the U.S. imports 1,000-2,000 tons of frog legs annually, while France imports 3.4 million tons annually (Stebbins and Cohen 1995). Amphibians and reptiles have been extremely important to studies of vertebrate anatomy, neurology, physiology, embryology, developmental biology, genetics, evolutionary biology, animal behavior, and community ecology (Stebbins and Cohen 1995, Petranka 1998, and Pough et al. 1998). Amphibian eggs and larvae have been extensively used in toxicological studies on the effects of chemical contaminants that may impact human health (Harfenist et al. 1989). Skin secretions of some amphibians show promise as antibiotics and as nonaddictive pain killers that are 200 times more powerful than morphine (Stebbins and Cohen 1995). The venoms of many snakes are being used to fight metastasizing cancers (Trikha et al. 1994), prevent thromboses that cause heart attacks and strokes (Lathan et al. 1996), and help understand diseases such as lupus (Court 1997). Amphibians are important in the control of insect pests such as mosquitoes, and many snakes control rodents that threaten crop damage (Pough et al. 1998). Amphibians and reptiles are also important reminders of some of the most significant events in the evolution of vertebrate life, the movement into the terrestrial environment by amphibians some 360 million years ago and the gaining of independence from aquatic environments by reptiles some 260 million years ago (Pough et al. 1998). Finally, some amphibians and reptiles are valuable bioindicators of environmental health because amphibians have highly permeable skin and egg membranes and complex life cycles with aquatic and terrestrial life history stages and both amphibians and reptiles are often philopatric to specific breeding, foraging, and overwintering habitats connected by habitats suitable for migration (Turner 1957, Bauerle et al. 1975, Duellman and Trueb 1986, Weygoldt 1989, Wake 1991, Olson 1992, Blaustein 1993, 1994, and Welsh and Ollivier 1998).

Status

In the past few hundred years, increases in human population and our ability to impact natural ecosystems have led to a dramatic increase in the global rate of species extinction (Wilson and Peter 1988). Within this overall biodiversity crisis, evidence has accumulated during the past few decades that amphibians around the globe may be declining at a higher rate than other taxonomic groups (Blaustein and Wake 1990, Phillips 1990, Wyman 1990, Wake and Morowitz 1991, Drost and Fellers 1996, but see Pechmann and Wilbur 1994). In North America, amphibian declines have been most numerous in the West and have occurred among species that occupy a variety of elevations, habitat types, and disturbance regimes (Corn 1994). Many reptiles have also declined (e.g., Dodd 1988, Garber and Burger 1995, Grover and DeFalco 1995, and Greene 1997), but these declines have not generated as much public or scientific interest.

Seven major factors, and their interaction, have been implicated as causative agents of amphibian declines. These include: (1) loss, deterioration, and fragmentation of aquatic and terrestrial habitats (e.g., Bury et al. 1980, Schwalbe 1993, Van Rooy and Stumpel 1995, Lind et al. 1996, and Beebee 1997); (2) introduction of nonindigenous species (e.g., Bradford 1989, Fisher and Schaffer 1996, Gamradt and Kats 1996, Kupferberg 1996, Adams 1997, Hecnar and M`Closkey 1997, and Kiesecker and Blaustein 1997*a*); (3) environmental pollutants (e.g., Lewis et al. 1985, Kirk

1988, Beebee et al. 1990, and Dunson et al. 1992); (4) increased ambient UV-B radiation (e.g., Blaustein et al. 1994a, Blaustein et al. 1995, Kiesecker and Blaustein 1995, and Nagl and Hofer 1997); (5) climate change (e.g., Pounds and Crump 1994, Stewart 1995, and Pounds et al. 1999); (6) pathogens (e.g., Carey 1993, Kiesecker and Blaustein 1997*b*, Berger et al. 1998, and Lips 1999); and (7) human commerce (e.g. Nace and Rosen 1979, Jennings and Hayes 1985, Buck 1997, and Pough et al. 1998). Not suprisingly, a majority of these factors have also been implicated as causative agents of reptile declines and the overall decline in biodiversity (e.g., Dodd 1988, Wilson and Peters 1988, Henderson 1992, Weir 1992, Guillete et al. 1994, Ballinger and Watts 1995, and Wilkinson 1996*b*). Thus, the conspicuous decline of amphibian populations may indeed be a good indication of the declining health of our environment.

The most up-to-date Montana Natural Heritage Program, U.S. Forest Service, Bureau of Land Management and Montana Fish, Wildlife, and Parks status ranks for Montana's amphibians and reptiles are shown in Appendix B; no herpetofauna in Montana have been or are being considered for listing under the federal Endangered Species Act. Unfortunately, for most herpetofauna in Montana, the status ranks in Appendix B are largely a result of guesswork because we lack baseline data that would allow us to properly evaluate the current status and trends of populations. However, there is evidence that at least 3 species, the northern leopard frog (*Rana pipiens*), the boreal toad (*Bufo boreas boreas*), and the common garter snake (*Thamnophis sirtalis*), have undergone or may currently be undergoing declines. As has happened in many other western states and Canadian provinces, the northern leopard frog has become extinct throughout nearly all of its former range in western Montana and has apparently been extirpated from 80% of historic localities on the northwestern plains (Reichel and Flath 1995, Stebbins and Cohen 1995, and Koch et al. 1996). Although still widespread across the contiguous mountainous regions of Montana, recent surveys have failed to find boreal toads at most historical sites, have found them at less than 10% of sites with suitable habitat, and have found some evidence that breeding is being restricted to lower elevations (Maxell et al. 1998). These findings are of particular concern in light of declines in toad populations across a number of western states (Corn et al. 1989 and Stebbins and Cohen 1995). The common garter snake's range extends across the entire state, but it has rarely been encountered in recent surveys on the eastern plains (Reichel 1995, Hendricks and Reichel 1996, Rauscher 1998, and Roedel and Hendricks 1998). Furthermore, although there are problems associated with using ratios of species encountered to determine a species' status, the current ratio of 1 common garter snake encountered for every 10-15 western terrestrial garter snakes (*Thamnophis elegans*) may be indicative of declines in common garter snakes in western Montana when compared with historical reports that they were encountered as frequently as the western terrestrial garter snake (Koch et al. 1996, and Bryce Maxell, personal observation).

In addition to these species, there should be concern about the status of a number of others, including the plains spadefoot (*Scaphiopus bombifrons*), Great Plains toad (*Bufo cognatus*), Canadian toad (*Bufo hemiophrys*), snapping turtle (*Chelydra serpentina*), spiny softshell (*Apalone spinifera*), short-horned lizard (*Phrynosoma hernandezi*), sagebrush lizard (*Sceloporus graciosus*), western skink (*Eumeces skiltonianus*), western hognose snake (*Heterodon nasicus*), smooth green snake (*Opheodrys vernalis*), and milk snake (*Lampropeltis triangulum*). There are relatively few historic records for these species and recent surveys either failed to detect them in a number of areas or were unlikely to detect them given the cryptic nature of the species and the limitations of the survey methods used (e.g. Reichel 1995, Hendricks and Reichel 1996, Rauscher 1998, and Roedel and Hendricks 1998). It is quite possible that a number of these species could be extirpated from a part of their range or even go extinct across the state without anyone being aware of it due to the poor knowledge of the species' distributions and their responses to anthropogenic impacts. This point is highlighted by the findings of Hart et al. (1998) and Redmond et al. (1998) who recently determined that 60-70% of the predicted ranges of these species are in private lands without any formal protection from conversion of natural habitat types to anthropogenic habitat types. Finally, our lack of knowledge about the status of Montana's herpetofauna may be best illustrated by the fact that it is possible that 4 additional species, the Idaho giant salamander (*Dicamptodon aterrimus*), Great Basin spadefoot (*Scaphiopus intermontanus*), wood frog (*Rana sylvatica*), and pygmy short-horned lizard (*Phrynosoma douglasi*), are present in the state, but have yet to be properly documented as a result of the paucity of survey work that has been done (Maxell, In Press).

Issues of Concern

Montana's 13 native amphibians and 17 native reptiles occupy a diverse array of habitats and vary greatly in their life history patterns (Reichel and Flath 1995, and Hart et al. 1998). Furthermore, relatively few studies have investigated the impacts of human recreation and travel activities on herpetofauna. Thus, identification of all possible impacts of recreation and travel activities on herpetofauna, and development of a comprehensive set of guidelines that would mitigate these impacts, are not possible at this time. However, a review of the scientific literature has allowed us to identify: (1) recreational and travel activities that are most likely to impact Montana's herpetofauna; (2) key characteristics of the biology of herpetofauna that need to be addressed in order to minimize the impacts of these activities; (3) a general set of guidelines that would allow human recreational and travel impacts to be minimized; and (4) major habitat types and associated species that should be addressed by resource managers.

Possibly the most important feature of the biology of amphibians and reptiles that management plans need to address is their use of habitats and the migrations they undergo in order to use them. At higher latitudes all herpetofauna require suitable breeding/rearing, foraging and overwintering habitats in order to survive (e.g., Turner 1957, Dole 1965, Ewert 1969, McAuliffe 1978, and King 1990). Many amphibians require warmer lentic waters with aquatic vegetation for breeding/rearing habitat, riparian areas that support large insect populations for foraging habitat, and terrestrial burrows, forest litter, or deep waters that are unlikely to freeze for overwintering habitats (Nussbaum et al. 1983, and Stebbins and Cohen 1995). Many reptiles require habitats with adequate sun exposure and substrates appropriate for nesting or maternal basking, habitats that support insect, fish, amphibian, mammal, or bird populations for foraging, and deep aquatic habitats with mud bottoms or deep rock crevices or mammal burrows that are unlikely to freeze for overwintering (Pough et al. 1998). Loss or exclusion from any one of these habitats, or loss of the resources they contain, may cause the species to decline or be extirpated from a local area unless individuals dispersing from nearby areas recolonize (e.g., Hecnar and M`Closkey 1996, and Patla 1997). In cases where all 3 of these habitats are present in a relatively small geographic area herpetofauna often do not undergo extensive migrations between overwintering, breeding, and foraging habitats (Sinsch 1990). In these instances, isolated populations may successfully perpetuate themselves unless the specific area is altered by natural succession or anthropogenic activity (e.g., Gulve 1994). In cases where the 3 required habitat types are isolated spatially, herpetofauna are capable of undertaking quite extensive seasonal migrations (e.g., Gregory and Stewart 1975, King 1990, Sinsch 1990, and Dodd 1996). In these instances, they are not only dependent on suitable breeding, foraging and overwintering habitats, but are also dependent on habitats suitable for migration (Dodd and Cade 1998). Coupled with the importance of considering all habitat requirements is the importance of considering the extreme philopatry shown by many herpetofauna species to the same breeding, foraging and overwintering sites year after year (Daugherty and Sheldon 1982, Sinsch 1990, Stebbins and Cohen 1995, and Pough et al. 1998). Thus, if these habitats are lost due to succession or anthropogenic alteration, or if individuals' abilities to migrate between them are hindered as a result of anthropogenic alteration of habitat then the species may be extirpated from an area.

The specific habitat requirements and predicted distributions of Montana's amphibians and reptiles were recently reviewed in the Montana Atlas of Terrestrial Vertebrates (Hart et al. 1998). This document summarizes the ranges, describes the habitat requirements of each life history stage, provides a list of key references on habitat use, and models predicted distributions for each species. The Montana Gap Analysis Final Report (Redmond et al. 1998) recently summarized species richness for amphibians and reptiles across the state and identified the proportion of lands under a variety of land stewardship regimes for each species individually and for amphibians and reptiles as entire taxonomic groups. In addition, Maxell et al. (In Review) reviewed the history of the study of herpetology in Montana, reviewed the status of Montana's herpetofauna, gave a list of all known museum records, gave dot-distribution maps for museum and observation records, and compiled an indexed bibliography of all known published and gray literature on Montana's herpetofauna. Together these reports provide the most up-to-date and comprehensive understanding of the distribution, status, and habitat use of Montana's herpetofauna and should be used by state and federal agencies, tribal governments, and private individuals in the direct development of large-scale management plans and as a reference when making smaller-scale management decisions. As a supplement to the information supplied in these reports, and for the reader's reference, we have summarized major habitat types and the amphibians and reptiles associated with each in Table 2.1.

A review of the scientific literature identified six major themes that encompass the major impacts that recreation and travel activities are likely to have on Montana's herpetofauna. They are:

1. Nonindigenous species and their management
2. Road and trail development and on- and off-road vehicle use
3. Development and management of recreational facilities and water impoundments
4. Harvest and commerce

5. Habitat fragmentation and metapopulation impacts
6. Lack of information / research needs

Specific areas of concern associated with each of these themes and a general set of management guidelines that would allow human recreational and travel impacts to be minimized are addressed individually in the remainder of the chapter.

NONINDIGENOUS SPECIES AND THEIR MANAGEMENT

Background

During the last 10-20,000 years humans have both knowingly and unwittingly increased the rate of invasions of nonindigenous species to the extent that they are now, and will continue to be, one of the leading threats to biological diversity around the globe (Elton 1958 and Soulé 1990). The most successful invaders have been species that are commensals with humans through their use as food, shelter, sport, or biotic control and they have been most successful at invading early successional or disturbed habitats (MacAthur and Wilson 1967 and Lodge 1993). Unfortunately, many of our attempts to control these nonindigenous species have further harmed our native species (e.g. Pimental 1971, Kirk 1988, and Fontenot et al. 1994). In Montana, the introduction of nonindigenous fish, bullfrogs, weeds, and pathogens, and attempts to remove or control nonindigenous fish and weeds may be one of the most important categories of threat to the native herpetofauna.

Impacts of Nonindigenous Fish

At least 52 species of fish belonging to 14 families have been introduced in Montana (Nico and Fuller 1999 and Fuller et al. 1999). Of these species, 9 belonging to 3 families have been widely introduced for recreational fishing and have been implicated in the decline of native amphibians across the globe (Sexton and Phillips 1986, Bahls 1992, Bradford et al. 1993, Bronmark and Endenhamn 1994, Brana et al. 1996, Hecnar and M`Closkey 1997a, and Fuller et al. 1999). These species include pumpkinseed (*Lepomis gibbosus*), blue gill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), and smallmouth bass (*Micropterus dolomieu*) in the family Centrarchidae, yellow perch (*Perca flavescens*) in the family Percidae, and rainbow trout (*Oncorhynchus mykiss*), cutthroat trout (*Oncorhynchus clarki*), brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*) in the family Salmonidae. Introductions of warm water centrarchids and percids and cold water salmonids have undoubtedly been made into a number of low-elevation water bodies that support or formerly supported amphibian communities. However, introductions of salmonids at higher elevations, which began as early as the 1880s (Jordan 1891), are likely to have had a particularly important impact on native amphibian communities inhabiting high (>800 meters) mountain lakes because 95% of these lakes in the western United States were naturally fishless prior to stocking (Bahls 1992). Thus, historically, as many as 15,000 lakes at elevations greater than 800 meters in the western United States may have supported native amphibian communities without the threat of predation or competition from fish. Presently, about 9,500 of the West's high-elevation lakes and virtually all of the deeper lakes contain introduced salmonids (Bahls 1992). In Montana, approximately 47% of the state's 1,650 high-elevation lakes now contain nonindigenous salmonids (Bahls 1992).

Egg, larval, and adult amphibians may be subject to direct predation by introduced warm and cold water fishes (e.g.s, Korschgen and Baskett 1963, Licht 1969, Semlitsch and Gibbons 1988, and Liss and Larson 1991). Similarly, all 3 amphibian life history stages are likely to be indirectly effected by the threat of predation due to (1) adult avoidance of oviposition sites where predators are present (e.g. Resetarits and Wilbur 1989 and Hopey and Petranka 1994), (2) decreased larval foraging and, therefore, growth rates as a result of staying in refuges to avoid predators (e.g., Figiel and Semlitsch 1990, Skelly 1992, Kiesecker and Blaustein 1998, and Tyler et al. 1998b), and (3) decreased adult foraging, growth rates, and overwinter survival as a result of avoiding areas with fishes (e.g., Bradford 1983).
Reptiles, particularly younger age classes, are likely to be directly preyed on by nonindigenous fish (Bryce Maxell, personal observation) and are also likely to be negatively effected indirectly as a result of the loss of amphibians, which they depend on as prey (e.g., Jennings et al. 1992 and Koch et al. 1996).

Impacts of Chemical Management of Sport Fisheries

Rotenone and commercial piscicides containing rotenone have often been used to remove unwanted fish stocks from a variety of aquatic habitats (Schnick 1974). The impacts of rotenone-containing piscicides on amphibians and turtles were recently reviewed by Fontenot et al. (1994) and McCoid and Bettoli (1996). They found the range of lethal doses of rotenone-containing piscicides for amphibian larvae and turtles (0.1-0.580 mg/L) to overlap to a large extent with lethal doses for fish (0.0165-0.665 mg/L), and to be much lower than the concentrations commonly used in fisheries management (0.5-3.0 mg/L). Furthermore, they reviewed, a number of studies that noted substantial mortality of nontarget turtles and amphibian larvae. However, the effects of rotenone on turtles and newly metamorphosed and adult amphibians was found to vary with the degree of each species' aquatic respiration and their likelihood of exiting treated water bodies (Fontenot et al. 1994 and McCoid and Bettoli 1996). Nontarget mortality of amphibian larvae was reduced by Hockin et al. (1985) by providing several untreated refuge areas that could be accessed through Netlon fence divisions and by protecting one refuge area containing high densities of amphibian larvae by placing a sheet of hessian sacking soaked in a saturated potassium permanganate solution that neutralized the rotenone. The nontarget effects of another piscicide, antimycin, have apparently not been formally studied, but preliminary observations seem to indicate that antimycin is also toxic to turtles and amphibian larvae (Patla 1998). In Montana all amphibian larvae as well as tailed frog (*Ascaphus truei*) adults and highly aquatic spiny softshells and snapping turtles either use some sort of aquatic respiration or may be unlikely to exit treated water bodies depending on the time of day and presence/absence of humans (Daugherty and Sheldon 1982 and Ernst et al. 1994). Thus, all of these species are likely to suffer mortality through the application of piscicides.

Impacts of Nonindigenous Bullfrogs

Bullfrogs (*Rana catesbeiana*) are native to the United States east of a line extending from northwest Wisconsin to south central Texas (Bury and Whelan 1984). However, they have now been widely introduced into permanent waters in all lower forty-eight states, with the possible exception of North Dakota, and have been implicated in the declines of a number of amphibian and reptile species throughout this area (Moyle 1973, Hammerson 1982, Bury and Whelan 1984, Kupferberg 1994, Rosen et al. 1995, Kupferberg 1997, and Lawler et al. 1999). The impetus for bullfrog introduction seems largely to be due to their use as a recreational hunting and food item, apparently, in some cases, as a result of native frogs having already declined because of human hunting and consumption (Bury and Whelan 1984 and Jennings and Hayes 1985). In Montana, bullfrogs were introduced for unknown reasons into the Bitterroot Valley sometime prior to 1968 and more than 20 distinct populations have now been reported along the Bitterroot, Flathead and Clark Fork Rivers and at a few other isolated localities around the state (Black 1969*a*, 1969*b*, Werner and Reichel 1994, Reichel 1995, Hendricks and Reichel 1996, Werner et al. 1998, and Maxell, In Press). Unfortunately, bullfrogs continue to be introduced into new sites from source populations both inside and outside of Montana despite the fact that unauthorized introduction or transplantation of wildlife into the natural environment is prohibited by Montana law (Bryce Maxell, personal observation and Levell 1995; MCA 87-5-711). The Montana state legislature could further prohibit the introduction of bullfrogs by designating them a species that is detrimental to Montana's native flora and fauna (Levell 1995; MCA 87-5-712).

All 3 life history stages of amphibians, as well as smaller aquatic reptiles, may be subject to direct predation by adult bullfrogs (e.g.s, Korschgen and Baskett 1963, Carpenter and Morrison 1973, Bury and Whelan 1984, and Clarkson and DeVos 1986). Additionally, both the eggs and larvae of native amphibians may be preyed upon by larval bullfrogs (e.g., Ehrlich 1979 and Kiesecker and Blaustein 1997*b*). Furthermore, egg, larval and adult amphibians are also likely to be indirectly effected by the threat of predation due to (1) adult avoidance of oviposition sites where predators are present (e.g., Resetarits and Wilbur 1989), (2) decreased larval foraging and, therefore, growth rates as a result of staying in refuges to avoid predators (e.g., Kiesecker 1997 and Kiesecker and Blaustein 1998), and (3) decreased adult foraging and growth rates as a result of avoiding areas with bullfrogs. Native amphibian larvae or adults may also be subject to chemically mediated interference competition (e.g., Petranka 1989 and Griffiths et al. 1993) or exploitative competition for resources (e.g., Kupferberg 1997). Finally, reptile predators that are dependent on larval or adult amphibians as a food source may also be impacted as a result of the loss of native amphibian larvae and the presence of larger bullfrog tadpoles and adults that they are unable to efficiently forage on (e.g., Kupferberg 1994).

Impacts of Nonindigenous Species as Vectors for Pathogens

Reports of mass mortality of amphibians due to pathogens are increasingly common (e.g., Nyman 1986, Worthylake and Hovingh 1989, Carey 1993, Blaustein et al. 1994b, Berger et al. 1998, and Lips 1999). Nonindigenous species, such as the bullfrog and centrarchid, percid, and salmonid fishes, may act as vectors for pathogens of herpetofauna. For example, *Saprolegnia*, a common pathogen of fish species reared and released from fish hatcheries, has recently been associated with declines of amphibian populations (Blaustein et al. 1994b). Releasing hatchery-raised fish may, therefore, increase the inoculation rate and lead to declines in native amphibian populations. Laurance et al. (1996) suggest that declines in stream-dwelling amphibian populations in Australia are caused by an unknown pathogen and hypothesize that nonindigenous species, such as the cane toad (*Bufo marinus*) and aquarium fish, are responsible for the introduction of the pathogen. Similarly, nonindigenous organisms may change environmental conditions leading to enhanced survival and number of pathogens. For example, Worthylake and Hovingh (1989) found that elevated nitrogen levels, caused by high numbers of sheep, increased bacterial concentrations and lead to periodic mass mortality of salamanders. Finally, pathogens may act synergistically with other natural and anthropogenically caused environmental stressors. For example, Kiesecker and Blaustein (1995) found that an interaction between UV-B radiation and *Saprolegnia* fungus enhanced the mortality of amphibian embryos.

Impacts of Weeds and Weed and Pest Management Activities

Noxious weeds may be spread by the use of off-road vehicles, watercraft, recreational livestock use, and camping activities. There is little knowledge of the impacts that weeds have on herpetofauna communities. However, nonindigenous aquatic and terrestrial weeds often form dense stands that are likely to exclude amphibian and reptile species that are sensitive to changes in microhabitat. For example, Germano and Hungerford (1981) and Scott (1996) report that lizards in the Sonoran Desert were sensitive to introduced grasses clogging their foraging, display, and escape pathways. Similarly, Reynolds (1979) found densities of sagebrush lizards and pygmy short-horned lizards were much lower in areas with introduced crested wheatgrass (*Agropyron cristatum*) than in areas with native big sagebrush (*Artemisia tridentata*) habitat on the Idaho National Engineering Laboratory. In addition to directly harming native species, the introduction of weed species may enhance the probability of successful introduction of other exotic species. For example, there is some evidence that the survival of exotic bullfrogs is enhanced by the presence of exotic aquatic vegetation, which provides habitat more suitable to the bullfrogs (Kupferberg 1996).

Management of weeds and insect pests with chemical herbicides and pesticides can have major impacts on herpetofauna communities. In particular, several features of amphibian biology may enhance their susceptibility to chemical contamination (Stebbins and Cohen 1995). The life history of most amphibians involves both aquatic larvae and terrestrial adults, allowing exposure to toxicants in both habitats. Many amphibians have skin with vascularization in the epidermis and little keritinization, allowing easy absorption of many toxicants. In fact, many studies have demonstrated the effects of chemical contamination on amphibians (reviewed in Cooke 1981, Hall and Henry 1992, Boyer and Grue 1995, and Carey and Bryant 1995). The effects range from direct mortality to sublethal effects such as depressed disease resistance, inhibition of growth and development, decreased reproductive ability, inhibition of predator avoidance behaviors, and morphological abnormalities.

Currently, there are no requirements for testing the toxicity of herbicides and pesticides on amphibians or reptiles (Hall and Henry 1992). Furthermore, there are no water quality criteria established for herpetofauna (Boyer and Grue 1995). It is often assumed that criteria for mammals, birds, and fish will incorporate the protection needed for amphibians and reptiles. The few chemicals that have been tested with fish and larval amphibians suggest that tadpoles may be more vulnerable to some toxicants than others (Hall and Henry 1992 and Boyer and Grue 1995). Several studies have examined the acute (lethal) toxicity of herbicides and pesticides on amphibians. Saunders (1970) and Harfenist et al. (1989) reviewed the effects of 25 and 211 different pollutants, respectively. However, it is important to recognize sublethal effects as well. Johnson and Prine (1976) found that organophosphates affect the thermal tolerance of western toad (*Bufo boreas*) tadpoles. Polychlorinated biphenyls (PCBs) and organochlorines can disrupt corticosterone production and inhibit glucogenesis (Gendron et al. 1997). Many pesticides result in decreased growth rate and inhibition of a predator response in amphibians (e.g., Berrill et al. 1993 and Berrill et al. 1994). Few studies have examined the effects of herbicides and pesticides on reptiles (Hall and Henry 1992). However, Hall and Clark (1982) found that *Anolis* lizards were at least as sensitive as birds and mammals to organophosphates. Also, some (PCBs) and DDT are known to act as estrogens, resulting in skewed gender ratios and gonad abnormalities in turtles (Bergeron et al. 1994) and alligators (Guillette et al. 1994).

Many of the newer pesticides and herbicides are designed to decompose soon after application. Although still toxic, presumably this reduces the impact area and, thus, the number of exposed individuals. However, many of the older chemicals may still be present in sediments. For example, Russell et al. (1995) found potentially toxic levels of DDT in tissues of spring peepers (*Pseudacris crucifer*) at Point Pelee National Park, Ontario, even though DDT had not been used in the area for 26 years. Levels as high as 1,188 µg/kg of DDT were found in spring peepers and implicate DDT as a possible causative agent in the local extinction of several amphibian populations.

<u>Guidelines Pertaining to Nonindigenous Species and Their Management</u>

1. The impacts of introduced fish, bullfrogs, weeds, and pathogens on Montana's native amphibians and reptiles should be formally investigated.
2. Introduction of nonindigenous fish species should be limited to areas where they have already been introduced and nonindigenous fish should be removed from waters that act as key overwintering or breeding sites for amphibians.
3. Streams and lakes should be thoroughly surveyed for amphibians and turtles prior to and after the application of piscicides in order to identify impacts of piscicide application.
4. If lakes are to be treated with piscicides, they should be treated in late summer after most amphibian larvae have metamorphosed and before amphibians and turtles enter deeper water bodies for overwintering. When amphibians and turtles are present an effort should be made to remove them before treatments begin.
5. Piscicides should not be used in streams containing tailed frogs because of the possibility of removing multiple larval and adult cohorts. Other methods of removal should be explored in these instances. If piscicide use is the only option available then pretreatment gathering and posttreatment restocking of tailed frog tadpoles and adults should be undertaken and treatment should occur in the late evening hours so that adults are more likely to exit treated waters.
6. The public should be educated on the possible impacts of bullfrogs on native aquatic and terrestrial communities and be made aware of the fact that it is illegal to introduce them into the wild in Montana.
7. The impacts of commonly used herbicides and pesticides on Montana's herpetofauna should be formally investigated.
8. In the meantime herbicide and pesticide use should be limited to brands that rapidly decompose after application, and herbicides and pesticides should not be sprayed within 300 meters of water bodies or wetlands. Alternative methods of weed and pest removal should be used in these areas.

ROAD AND TRAIL DEVELOPMENT AND ON- AND OFF-ROAD VEHICLE USE

<u>Background</u>

Many recreational activities involve motorized use of roadways through public lands. Furthermore, off-road vehicle use is increasing in popularity and is extending the impacts of motorized traffic. Direct mortality from collisions with vehicles has been extensively documented for herpetofauna species. Several management options, from underpasses to road closures, may reduce such road kill. Although less studied, herpetofauna may also suffer from indirect impacts of motorized activities. Reduced habitat quality, habitat fragmentation, and vehicle noise may all be potentially important indirect impacts. In addition, many predators may use roads and trails to access sites with amphibian and reptile prey. Finally, several recreational activities may result in direct or indirect chemical contamination of herpetofauna habitat. For example, road, trail, or campground construction and off-road vehicle use can disturb soils laden with heavy metals or other toxicants leading to chemical contamination of waters.

<u>Road Kill</u>

Many studies have documented the large number of amphibians and reptiles that are killed on roadways (e.g., Campbell 1956, Van Gelder 1973, Dodd et al. 1989, Bernardino and Dalrymple 1992, Fahrig et al. 1995, and Rosen and Lowe 1994). For example, Rosen and Lowe (1994) estimated that 13.5 snakes/kilometer/year were killed on state highways in southern Arizona. Campbell (1956) estimated that between 10,000 and 25,000 snakes per year were killed on roads in New Mexico in the early 1950's. Ehmann and Cogger (1985) estimated that five million reptiles and frogs are killed annually on Australian roads. One study has even documented motorist tendencies to swerve out of their way to ensure hitting snakes (Langley et al. 1989). However, snakes are not the only victims. Where U.S. Highway 93 intersects the Ninepipe National Wildlife Refuge in Montana, at least 205 western painted turtles (*Chrysemys picta bellii*) were killed along a 7.2 kilometer stretch of highway in a single field season (Fowle 1996). Many amphibians undergo mass migrations to and from breeding habitats and may be killed in the thousands while crossing roads (e.g., Koch and Peterson 1995 and Langton 1989).

Although the number of mortalities reported in road-kill studies is alarming, only a few studies have taken the extra step to demonstrate an impact of such mortality at the population level (e.g., Lehtinen et al. 1999). Population density of western painted turtles was positively associated with distance from U.S. Highway 93 in Montana (Fowle 1996). Similarly, Vos and Chardon (1998) found that the density of roads within 250 meters of a pond site was negatively associated with the size of moor frog (*Rana arvalis*) populations. Furthermore, the density of roads within 750 meters of a pond site was negatively associated with the probability that the pond would be occupied at all. In another study Van Gelder (1973) estimated that 30% of the females from a local breeding population of the common toad (*Bufo bufo*) succumbed to road kill and an equivalent percentage for males was likely. Finally, in a study of frogs and toads, Fahrig et al. (1995) found the proportion of dead-to-live animals increased and the total density of animals decreased with increasing traffic intensity.

Several management options are available to reduce traffic mortality on established roads including culverts or underpasses, temporary road closures during major migrations, reduced speed zones, or relocating roads (Langton 1989, Bush et al. 1991, Bernardino and Dalrymple 1992, Yanes et al. 1995, and Boarman and Sazaki 1996). Boarman and Sazaki (1996) found that drift fences and culverts effectively reduced road mortality for the threatened desert tortoise (*Gopherus agassizii*). Spotted salamanders (*Ambystoma maculatum*) also appear to successfully use culverts (Jackson and Tyning 1989). However, Auiderwijk (1989) reported that less than 4% of a local toad population used culverts installed for their migration. Yanes et al. (1995) suggest that culvert dimensions, road width, height of drift fence, and vegetation along roadways may all influence the effectiveness of culverts. Funnels leading into culverts, vegetation around culvert openings and pitfall-trap entrances may all enhance the effectiveness of culverts. Many other suggestions for constructing effective culverts can be found in the studies reported by Langton (1989).

Off-Road Vehicle Impacts

The impacts of motorized vehicles on amphibian and reptile populations do not end at the roadside. Although far less studied, impacts from ORVs have been documented. In addition to direct mortality resulting from collisions, ORVs may disrupt habitat to the point that it becomes unusable by herpetofauna. Busack and Bury (1974) established 3 plots, each 1 hectare in size, in areas where the vegetation had been heavily damaged by ORVs, moderately damaged by ORVs and little damaged by ORVs. Of 4 lizard species found in the area, 2 specimens were captured in the heavily damaged site compared to 15 and 24 in the moderately and little damaged sites respectively. In a similar study, Bury et al. (1977) established replicate plots arranged into 4 ORV-use categories; control, moderate, heavy and "pit areas" (the latter are concentrated-use areas). Eight reptile species were captured during 3 days of sampling, and the total number of individuals differed between the plot types. Moderate use, heavy use, and pit areas had 31%, 72%, and 85% fewer reptiles respectively than the control plots. The study also found that numbers of birds and mammals, potential prey for some herpetofauna, were reduced in ORV-use areas.

Noise from on- and off-road vehicles is also likely to have negative indirect impacts on herpetofauna. For example, Nash et al. (1970) found that leopard frogs exposed to loud noises (120 decibels) remained immobilized for much longer periods of time than a similarly handled control group. Thus, an immobility reaction resulting from noise-induced fear could increase mortality of herpetofauna that inhabit areas used by ORVs or for herpetofauna undertaking road crossings by inhibiting their ability to find shelter or move across a roadway. Similarly, studies in the Sonoran Desert found that motorcycle and dune buggy sounds (≥ 100 decibels) decreased the acoustical sensitivities of a number of lizard species (Bondello 1976 and Brattstrom and Bondello 1979). Some species were particularly sensitive to these sounds and exposures as short as 8 minutes in duration resulted in actual hearing loss (Brattstrom and Bondello 1979). Thus, vehicle noise may indirectly cause mortality by eliminating the species' ability to detect and capture necessary food items and detect and avoid predators. Although we found no studies documenting the impacts of noise on breeding choruses of amphibians, it is also possible that vehicle noise may not allow amphibians to properly hear and move toward breeding aggregations. This may be especially true for species such as our native Columbia spotted frog (*Rana luteiventris*) and boreal toad, which do not have loud calls and may not be heard from long distances or in the presence of other noises.

Chemical Contamination and Sedimentation from Roads

Soil disturbance has been directly implicated in both lethal and sublethal effects on amphibians. If not contained, road construction may cause increased sedimentation in adjoining aquatic habitats. Road construction in Redwood National Park introduced large amounts of sediments into neighboring streams and densities of tailed frogs, Pacific giant salamanders (*Dicamptodon tenebrosus*), and southern torrent salamanders (*Rhyacotriton variegatus*) were lower in these streams compared to nearby control streams (Welsh and Ollivier 1998). The impacts of sedimentation may be further heightened if the sediments contain toxic materials. Road construction in Great Smoky Mountains National Park involved using fill from the Anakeestra rock formation that, when oxidized, formed a leachate with sulfuric acid, iron, zinc, manganese, and aluminum (Huckabee et al. 1975, Kucken et al. 1994). Runoff from roadsides and culverts resulted in contamination of streams within the park and 2 stream breeding salamander species were eliminated and 2 other species exhibited a 50% reduction in population size. Declines in macroinvertebrates and fish were also noted. Similarly, disturbance of, and runoff from, mine tailings increased the acidity and heavy metal concentrations in a drainage system in Colorado (Porter and Hakanson 1976). Laboratory bioassays indicated that water in the drainage was lethal for western toad larvae and required a 1000 fold dilution before tadpoles were able to survive. Sublethal effects may also result from heavy metal poisoning (e.g., Lefcort et al. 1998). Deformities in the oral cavity were observed in bullfrog tadpoles exposed to sediments high in arsenic, barium, cadmium, chromium, and selenium (Rowe et al. 1998), and southern toads (*Bufo terrestris*) exposed to coal combustion wastes had elevated levels of stress hormones (Hopkins et al. 1997).

Contaminated runoff from roads or campground surfaces may also affect amphibians. Lead concentrations in frog tadpoles living in roadside ponds and ditches were correlated with daily traffic volumes in Maryland and Virginia (Birdsall et al. 1986). Concentrations as high as 270 mg/kg were discovered; levels that are associated with decreased reproduction and growth. Petroleum products may also contaminate aquatic habitats next to roadways or may be directly introduced from motorized watercraft. Mahaney (1994) examined the effects of crankcase oil on tadpoles of the green treefrog (*Hyla cinerea*). Concentrations of 100 mg/L inhibited tadpole growth and prevented metamorphosis.

Guidelines Pertaining to Road and Trail Development and On- and Off-Road Vehicle Use

1. The impacts of road and trail development, on- and off-road vehicle use, and watercraft use on Montana's herpetofauna should be formally studied, especially in areas of high human use.
2. Potential road and trail routes should be thoroughly surveyed for amphibians and reptiles in order to identify impacts of road or trail construction and vehicle use.
3. When possible roads and trails should avoid water bodies, wetlands, and denning sites that are key habitats for amphibians and reptiles.
4. When new roads and trails must be constructed near water bodies or wetlands care should be taken to avoid increased sedimentation, maintain the essential hydrographic period, and allow natural processes, such as changes in river courses to continue.
5. Areas identified as key migration routes should either be closed to vehicle use during peak migration periods or culverts and underpasses should be constructed in conjunction with drift fences in order to minimize road mortality.
6. ORV use should be restricted to designated roads, trails, or pit areas.
7. Road and trail development and off-road vehicle use in areas with soils that contain mine tailings or other toxic substances should be prevented. If road and trail construction is absolutely necessary in these areas then reclamation activities should be undertaken prior to road or trail construction.

DEVELOPMENT AND MANAGEMENT OF WATER IMPOUNDMENTS AND RECREATIONAL FACILITIES

Background

The development of recreational facilities, including the development of water impoundments, may result in the loss of key breeding, foraging, and overwintering habitats for herpetofauna. Recreational facilities also often bring people and their pets into direct contact with native wildlife and, in some cases, herpetofauna may be negatively impacted by this contact. In addition, recreational facilities may also have negative impacts on herpetofauna through artificial lighting sources, which may alter their behavior, and by subsidizing native predators, which may survive at artificially high numbers through the use of human resources while continuing to prey on native herpetofauna.

Impacts from Water Impoundments

Water impoundments provide a variety of recreational opportunities including fishing, hunting, swimming, boating, and camping. In some cases these water impoundments may create breeding, foraging, and overwintering habitat for herpetofauna in areas that were previously inhospitable (Cooper et al. 1998). However, in a number instances, the development of water impoundments can result in the loss of key breeding, overwintering, and foraging habitats for herpetofauna. For example, development of a series of water impoundments along the Colorado River in Texas extirpated the Concho water snake (*Nerodia harteri paucimaculata*), a species that depends on riffle habitats, from much of its historic range, eventually leading to its federal listing as an endangered species (Mathews 1989). Similarly, the construction of Jordanelle Reservoir on the Provo River in Utah flooded a large amount of habitat used by Columbia spotted frogs, a species that is threatened in the region (Wilkinson 1996a). Water impoundments can also cause downstream riverine habitats to deteriorate as a result of changes in flow regimes. Lind et al. (1996) found that reduced water flows below dams on the Trinity River in California resulted in the loss of flood plain breeding pools and vegetational overgrowth of riparian areas used for basking and foraging by amphibians.

Furthermore, manipulation of water levels in water impoundments can result in direct and indirect mortality of amphibian larvae and eggs. For example, during the summer of 1998, fluctuating water levels in Cabinet Gorge Reservoir in northwest Montana led to the desiccation of Columbia spotted frog eggs and larvae when water levels dropped for power generation (Bryce Maxell, personal observation). Fluctuations in water levels may also cause a decline in water temperatures as a result of increased water movement. Colder water temperatures may increase mortality by decreasing larval growth rates and increasing the length of the larval life history stage (Wilbur 1980). Colder water temperatures can also result in a decreased immune response, leaving amphibian larvae more susceptible to pathogens (Nyman 1986, Carey 1993, and Maniero and Carey 1997). Some factors associated with water level fluctuations may interact in a complex manner resulting in amphibian mortality. For example, Worthylake and Hovingh (1989) describe periodic mass mortality of tiger salamanders (*Ambystoma tigrinum*) caused by interactions between fluctuating water levels, high numbers of sheep, and high levels of a pathogenic bacteria (*Acinetobacter* spp.). High numbers of sheep increased the nitrogen input into the lake and, combined with low water levels, resulted in high nitrogen concentrations that were conducive to the pathogen. Kiesecker and Blaustein (1997a) describe another complex interaction. Western toads apparently lay their eggs in one particular portion of an Oregon lake, regardless of the water levels. Low water levels resulted in mass mortality of toad eggs due to the synergistic effect of UV-B radiation and the pathogenic fungus *Saprolegnia*. Moving eggs to deeper waters significantly reduced egg mortality.

Some water impoundments are managed exclusively for waterfowl production. Because many waterfowl and wading birds feed on amphibians and reptiles (Duellman and Trueb 1986), concentrated numbers of waterfowl may lead to increased depredation. Furthermore, high concentrations of migratory waterfowl have been associated with decreased water quality (Manny et al. 1994 and Post et al. 1998) and habitat degradation (Kerbes et al. 1990 and Ankney 1996). For example, Post et al. (1998) estimated that waterfowl increased nitrogen and phosphorus levels by 40% and 75%, respectively, on Bosque del Apache National Wildlife Refuge in the winter of 1995-1996, and Kerbes et al. (1990) reported that high concentrations of snow geese (*Chen caerulescens*) have lead to destruction of wetland vegetation.

Finally, although many of the negative impacts associated with water impoundments mentioned above are associated with amphibians, declines in amphibian populations resulting from water impoundments would also be expected to lead to declines in reptile predators that depend on amphibians as prey (Kupferberg 1994 and Koch et al. 1996).

Recreational Facilities

Several aspects of recreational facilities and associated activities may negatively impact herpetofauna. For example, Garber and Burger (1995) documented the decline in populations of wood turtle (*Clemmys insculpta*) during a 10-year time period as the result of a New England wildlife reserve being opened up to human recreation. Recreationists were required to obtain permits to use the reserve, and the rate of turtle declines was highly correlated with the number of permits issued each year, apparently as a result of removal by recreationists.

Amphibian and reptile populations in or near recreational facilities may be at risk of increased mortality as a result of handling and killing by humans. Herpetofauna may become stressed by human handling (e.g., Reinking et al. 1980) and, if translocated to unfamiliar microhabitats, may not be able to find local refugia from predators, or water to rehydrate themselves. Furthermore, people may intentionally kill herpetofauna that they feel threatened by, especially rattlesnakes and bullsnakes (*Pituophis catenifer*), which may be confused for rattlesnakes by people unfamiliar with their identification. This is unfortunate because all snakes in Montana, with the exception of the prairie rattlesnake (*Crotalus viridis viridis*), are nonvenomous, and all herpetofauna in Montana, including the prairie rattlesnake, pose little threat to human safety (Reichel and Flath 1995). Fewer than 2,000 people are bitten by venomous snakes each year in the United States and fewer than 10 of these incidents result in death; the chances that someone will be killed by lightning are greater than their chances of dying as a result of snakebite (Reichel and Flath 1995 and Greene 1997). Several recent studies support the idea that from the perspective of a relatively small snake that would never consider humans as food items and could easily be injured by them, it makes sense to: (1) avoid being detected by remaining concealed or fleeing, (2) if detected and threatened, bluff an attack, and (3) if the bluff does not work, bite as a last line of defense. For example, Prior and Weatherhead (1994) found that in 174 trials in which eastern Massasauga rattlesnakes (*Sistrurus catenatus*) were approached to within 0.5 meters or less the snake did not strike; snakes only bit when physically restrained. Similarly, Gibbons and Dorcas (1998) found that only 10% of the cottonmouths (*Agkistrodon piscivorus*) they intentionally stepped on while wearing snake-proof boots would bite the boot and only 40% of snakes picked up by glove-covered snake tongs would bite the glove.

Amphibian and reptile populations in or near recreational facilities may also face increased mortality as a result of handling and killing by human pets, stray dogs and cats, and a number of wild predators that are supported in larger numbers around areas of human activity. For example, domestic dogs and cats introduced to islands in the West Indies nearly extirpated a population of rock iguanas (*Cyclura carinata*) (Iverson 1978) and feral cats in Victoria, Australia commonly fed on frogs and lizards (Coman and Brunner 1972). In the United States there may be more than 120 million dogs and cats, with as many as 50 million of these being homeless (Denney 1974). The impact these dogs and cats have on herpetofauna populations is largely unknown. However, snakes and lizards were a common food item in the diets of feral cats in Oklahoma and Texas (McMurry and Sperry 1941 and Parmalee 1953) and it is possible that some herpetofauna populations in Montana could be impacted as well. Wild predators, including ravens (*Corvus corax*), striped skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), coyotes (*Canis latrans*), and foxes (*Vulpes vulpes*) may be supported at artificially high numbers around areas of human activity due to the availability of human refuse and a lack of larger predators. Olson (1989) found that ravens depredated more than 20% of a breeding aggregation of western toads in the Oregon Cascades. Similarly, Schaaf and Garton (1970) found that raccoons ate at least 50 individuals of a breeding chorus of American toads (*Bufo americanus*) and Christiansen and Gallaway (1984) found that predation of turtle nests was significantly higher in the presence of raccoons. In the Lee Metcalf National Wildlife Refuge in Montana, Corn and Hendricks (1998) found 75% of western painted turtle nests were destroyed by predators within 30 days of egg laying; based on tracks likely predators included skunks, coyotes, and raccoons.

Finally, a number of amphibians and reptiles breed and forage nocturnally and it is possible that artificial lighting at recreational facilities may negatively impact these activities. For example, large choruses of breeding Pacific treefrogs (*Hyla regilla*) in western Montana can be rapidly and completely quieted by shining a flashlight across a breeding pond, and calling may not be reinitiated for up to 5 minutes (Bryce Maxell, personal observation). If breeding ponds are subject to constant illumination by a fixed light or repeated exposure to car lights near a recreational facility it is possible that breeding success may be negatively impacted. Similarly, nocturnal foraging behavior of amphibians and reptiles may be impacted by the presence of artificial lights, especially when species depend on extremely dark conditions (e.g., Hailman 1982). Buchanan (1993) found that the ability of nocturnally foraging grey treefrogs (*Hyla versicolor*) to detect and subsequently consume prey was significantly reduced when artificial light sources were present as compared to ambient-light conditions. It would also be expected that nocturnally foraging snakes that depend on concealment from prey, which they recognize by olfactory cues, might have reduced foraging success in the presence of artificial light sources.

Guidelines Pertaining to Development and Management of Water Impoundments and Recreational Facilities

1. The impact of recreational facilities, water impoundments, and associated human activities on amphibian and reptile populations should be formally investigated.
2. Current and potential sites for recreational facilities and water impoundments should be thoroughly surveyed for amphibians and reptiles in order to identify potential impacts of these facilities on native species.
3. New recreational facilities should not be located within 300 meters of key breeding, foraging, or overwintering habitats.
4. When past or future water impoundments have eliminated key breeding, foraging, and overwintering habitats, impacts on amphibians should be mitigated by the creation of adjacent wetlands that have areas with deeper waters for overwintering and areas with shallow waters for larval rearing. Furthermore, fish should not be introduced to these water bodies and fluctuations in water levels at these sites should not be correlated with fluctuations in water levels in the adjacent water impoundment.
5. Downstream flows from water impoundments should mimic natural flow regimes in order to maintain flood plain breeding and foraging habitats.
6. Management of habitats exclusively for waterfowl production should be avoided. A multispecies or community approach is preferable.
7. Recreational facilities located near documented populations of amphibians and reptiles should contain educational signs or pamphlets pertaining to the amphibians and reptiles in the area and how humans and their pets may impact them. At recreational sites where rattlesnakes may be encountered information on reducing the risks of being bitten and emergency treatment for bites should be presented.
8. If domestic or wild predators are found in areas, such as key breeding or nesting habitat where native herpetofauna would naturally occur in high densities, predator control programs may be required in order to ensure that native herpetofauna communities will persist.
9. The subsidization of native predators should be minimized by maintaining fully enclosed waste facilities.

HARVEST AND COMMERCE

Impacts of Harvesting, Collecting, and Commerce

The worldwide collection and harvest of amphibians and reptiles for food, sport, and commerce as pets, skins, art, souvenirs, and medicinal products is extensive. Hundreds of millions of herpetofauna are removed from the wild and/or killed each year for these activities and annual worldwide commerce in herpetofauna may be valued in the hundreds of millions, perhaps even billions, of dollars (e.g., Wilkinson 1996b, Buck 1997, and Pough et al. 1998).

Unfortunately, we currently do not know the degree to which Montana's amphibians and reptiles are collected or harvested for biological or commercial purposes. However, it may be quite substantial based on the few observations and records we do have. The Montana Fish, Wildlife and Parks receives regular requests regarding permits for collecting amphibians and reptiles in Montana (Dennis Flath, Montana Fish, Wildlife, and Parks, personal communication). It would be expected that these collectors may be targeting rarer herpetofauna such as the Coeur d' Alene salamander (*Plethodon idahoensis*), short-horned lizard, western hognose snake, smooth green snake, and milk snake that are desired in the pet trade. However, most of the records we have for commercial collecting of herpetofauna in Montana are for the collecting of prairie rattlesnakes. For example, in the Fall of 1998, Montana Fish, Wildlife, and Parks was contacted by the Arizona Department of Fish and Game after they had stopped a man at a game check station with several hundred pounds of frozen rattlesnakes that he had collected in

Montana (Dennis Flath, Montana Fish, Wildlife, and Parks, personal communication). Furthermore, the scientific and public literature is full of references to prairie rattlesnakes that were collected in Montana. The author of an article in *Montana Wildlife* claims to have captured and killed 5,000 rattlesnakes in Beaverhead County, Montana during a 20-year period in which he also shipped many live snakes to zoos and sportsmen's clubs across the United States (Sweet 1953). In an article on some rattlesnakes that were shipped to him, Gloyd (1933) reports hundreds of rattlesnakes being killed at the point of collection, an apparent den site, near Sunburst, Montana. In another example, Dean et al. (1980) report receiving specimens from a commercial collector, the Montana Rattlesnake Company, based in Wilsall, Montana, which collected 23 gravid female rattlesnakes from the Missouri Breaks region of northern Montana.

Fortunately, there is no evidence that rattlesnake roundups have become a popular public event in Montana the way they have in more southern states (e.g., Black 1981, Clark 1991, and Weir 1992). These events can result in the collection of thousands of rattlesnakes, which are often subjected to inhumane treatments such as having gasoline or other chemicals poured into their dens to facilitate collection, allowing snakes to dehydrate or starve, suffocating snakes in "snake pits", pulling rattles off of live individuals, amputating tails of live individuals, and burning individuals alive (Clark 1991). Rattlesnake roundups may also result in the collection and killing of other herpetofauna species and the destruction of microhabitats, permanent shelters, and hibernacula used by a variety of herpetofauna (Campbell et al. 1989, and Warwick 1990).

Montana's 2 rarest species of turtles, the common snapping turtle and spiny softshell turtle, may also be the target of frequent harvest for human consumption because of the large body size attained by some adults. Unfortunately, populations of these turtles may be severely impacted by the harvest of larger sexually mature adults because the majority of turtles do not survive to sexual maturity (which may not be reached until the age of 16), and adults that do survive may produce offspring for decades (Congdon et al. 1993, and Congdon et al. 1994). Congdon et al. (1994) found that only a 10% increase in annual mortality of adult common snapping turtles over 15 years of age would halve the number of adults in less than 20 years.

Guidelines Pertaining to Harvest and Commerce

1. The degree to which amphibians and reptiles are harvested in Montana and the impacts of harvesting on populations of amphibians and reptiles should be formally studied.
2. Statutes that require permits for collecting or harvesting amphibians and reptiles should be clarified and updated.
3. Collecting or harvesting rare species such as the Coeur d' Alene salamander, common snapping turtle, spiny softshell turtle, short-horned lizard, western hognose snake, smooth green snake, and milk snake, which may be desired by the pet trade or for human consumption, should be prohibited in order to prevent declines in these species.
4. Rattlesnake roundups, as public events, should be prohibited.
5. A public education program should be undertaken in order to encourage people to enjoy and value amphibians and reptiles in the wild.

HABITAT LOSS AND METAPOPULATION IMPACTS

Many of the recreational activities described in this chapter, and anthropogenic impacts in general, may result in the loss and/or fragmentation of herpetofauna habitat. Roads, trails, ORV use, recreational facilities, and water impoundments can replace natural habitat, and this destruction can obviously displace herpetofauna populations (e.g., Bury et al. 1980, Dodd 1990, Lind et al. 1996, and Beebee 1997). Similarly, nonindigenous species, including fish and bullfrogs, can extirpate local populations of native herpetofauna (e.g., Rosen et al. 1995 and Knapp 1996). Loss of individual local populations may also influence the persistence of regional populations (generally referred to as metapopulations) even when the total amount of habitat remains constant (e.g., Hanski and Gilpin 1991, Robinson et al. 1992, Simberloff 1993, Fahrig and Merriam 1994, and Margules et al. 1994). For example, Rosen et al. (1995) found that extirpation of native amphibians in Arizona resulting from the introduction of nonindigenous bullfrogs and fishes into permanent water bodies also led to the extirpation of native amphibians from nearby regions when the smaller water bodies that the natives had been exiled to dried up during a drought. Thus, loss of core habitats that support local source populations can lead to more widespread extirpations.

Habitat patch size, shape, isolation, and quality all influence the persistence of regional collections of populations or metapopulations. The size of habitat patches is often associated with the probability that a patch is occupied by amphibian or reptile species (e.g., Laan and Verboom 1990, Branch et al. 1996, Marsh and Pearman 1997, Fahrig 1998, and Hokit et al. 1999). Patch distribution across a landscape may also greatly influence whether a patch is occupied or not. The degree of patch isolation is often negatively associated with patch occupancy (Sjögren 1991, Vos and Stumpel 1995, Branch et al. 1996, Sjögren-Gulve and Ray 1996, and Hokit et al. 1999). Even manipulating the matrix habitat in between habitat patches can influence patch occupancy. For example, Sjögren-Gulve and Ray (1996) found that ditches meant to drain forest areas between frog ponds effectively isolated them even though the distance between ponds had not been altered.

Another complication is that different species respond to patchy landscapes in different ways. The dispersal abilities of a species, both the distance it moves and its ability to move through matrix habitat, can greatly affect patch occupancy patterns. For example, Florida scrub lizards (*Sceloporus woodi*) and six-lined racerunners (*Cnemidophorus sexlineatus*) are similar in body size and habitat preferences, but the relatively low vagility of scrub lizards resulted in a restricted distribution across the same landscape of scrub habitat patches (Hokit et al. 1999). The different dispersal abilities of herpetofauna species can cause difficulty in defining a habitat patch and dispersal buffers around patches. Semlitsch (1998) found that six species of *Ambystoma* salamanders varied in their dispersal and use of habitat surrounding ponds. Some species dispersed and used terrestrial habitat up to 250 meters from the pond edge, suggesting that managers need to seriously consider providing extensive buffer zones surrounding water bodies and wetlands. Species may also differ with respect to their response to habitat edges. For instance, Demaynadier and Hunter (1998) found that while salamanders, frogs, and toads were all negatively effected by forest edges, salamanders were much more sensitive to abrupt forest edges than frogs and toads. On the other hand, northern alligator lizards (*Elgaria coerulea*) in Montana are positively affected by forest edges and may have increased rates of dispersal as a result of road cuts or forest clearcuts (Hart et al. 1998).

Guidelines Pertaining to Habitat Fragmentation

1. The effects of habitat fragmentation should be formally investigated for all amphibian and reptile species in Montana. Specifically, the degree to which each species tolerates habitat fragmentation should be identified.
2. Loss or deterioration of overwintering, breeding, foraging, or migration habitats used by various amphibian and reptile species should be avoided.
3. When loss or deterioration of overwintering, breeding, foraging, or migration habitat is unavoidable, mitigation measures should be addressed in order to ensure that regional populations of amphibians and reptiles are maintained.

OVERALL CONCLUSIONS

The relatively poor knowledge we have of the distribution, biology, and status of many of Montana's herpetofauna highlights the need to undertake thorough inventories of our public lands. Furthermore, the lack of knowledge of the distribution and status of many of these species makes it all the more important to properly manage recreational and travel activities that may impact them. This point is highlighted by the findings of Hart et al. (1998) and Redmond et al. (1998), which show that herpetofauna are relatively less protected by public lands than other terrestrial vertebrates in Montana. These findings emphasize the dual necessities of (1) properly protecting herpetofauna species on our public lands and (2) properly educating citizens so that they can appreciate herpetofauna and have a stake in protecting them on private lands, which herpetofauna largely depend on for survival.

Although recreational impacts on Montana herpetofauna have been little studied, the literature provides several examples of factors often associated with recreation that do affect amphibian and reptile populations. Nonindigenous species can directly affect herpetofauna via competition and predation, and management of nonindigenous species can indirectly affect herpetofauna as well. For example, piscicides, herbicides, and pesticides are known to impact amphibian populations. Road traffic and off-road vehicle use directly kill herpetofauna and indirectly impact populations by creating migration barriers, destroying habitats, and increasing chemical contamination and sedimentation. The development of recreational facilities and water impoundments may result in the loss of key breeding, foraging, and overwintering habitats for herpetofauna. Harvesting and collecting can have obvious impacts on herpetofauna populations and habitat loss may lead to fragmentation and disruption of metapopulation dynamics.

OVERALL GUIDELINES/RECOMMENDATIONS

Although we currently lack detailed knowledge of specific habitat requirements for many of Montana's herpetofauna as well as the impacts of various recreational and travel activities, this lack of knowledge should not deter us from making common sense decisions that are likely to provide protection to herpetofauna populations. Overall guidelines for recreational and travel activities follow and are based on our interpretation and synthesis of the available literature.

1. Thorough inventories of all state and federal lands should be conducted in order to determine the distribution and status of herpetofauna.
2. A statewide monitoring program should be established (similar to the breeding-bird survey) in which populations of herpetofauna near and away from human impacts are annually surveyed with calling surveys, egg and larval surveys, and pitfall and funnel trap surveys. Permanent sites should be chosen for year-to-year comparisons based on the presence of rarer species. If one person from each U.S. Forest Service district, Bureau of Land Management region, or Montana Fish, Wildlife and Parks region conducted 4-5 days of surveys each year, it would greatly increase our understanding of the status of herpetofauna populations and our ability to detect declines.
3. All state and federal field biologists should be trained in the identification of Montana's herpetofauna species. Biologists could be trained to identify all of the state's herpetofauna in a single, half-day training session.
4. All state and federal agencies should encourage personnel to report all incidental sightings of herpetofauna to the Montana Natural Heritage Program.
5. Formal research should be undertaken to identify the impacts of nonindigenous species, piscicides, pathogens, water impoundments, recreational facilities, habitat fragmentation, roads, and on- and off-road vehicles and watercraft on all of Montana's herpetofauna.
6. When possible, new recreational facilities or road and trail projects should not be constructed within 300 meters of key breeding, overwintering, or foraging sites. New water impoundments should not be constructed where they would flood key habitats.
7. Off-road vehicle use should be restricted to designated trails or play areas.
8. When unavoidable, impacts of recreation and travel activities should be mitigated by the creation of new habitat. New road projects should mitigate impacts to migrating herpetofauna by conducting surveys prior to construction and placing bridges or drift fence/tunnel systems in areas that intersect key migration routes.
9. Introduction of nonindigenous fish species and bullfrogs should be limited to areas where they have already been introduced, and fish and bullfrogs should be removed from sites that act as key overwintering or breeding sites for native herpetofauna.
10. Use of piscicides for fish removal should consider impacts on amphibians and aquatic reptiles and should be mitigated by conducting the removal in the fall after amphibian larvae have metamorphosed and before aquatic herpetofauna have moved to overwintering sites. Catching and holding herpetofauna in treated areas until piscicide levels have declined may be necessary.
11. Application of herbicides and pesticides should be excluded from within 300 meters of wetlands that act as key breeding, foraging, or overwintering habitats.
12. Educational programs on herpetofauna should be established, including the development of signs, posters, and outreach programs to schools.
13. Collecting permits for scientific research, harvest, and commerce should be required in order to track these activities and control their impacts on herpetofauna populations. Laws should be enacted that limit the taking of Montana's herpetofauna for the pet trade.
14. The management status of all herpetofauna on U.S. Forest Service and Bureau of Land Management lands should be reviewed.

INFORMATION NEEDS

Informational needs on Montana's herpetofauna are extensive. There is a lack of information on species' distributions within the state and, in many cases, basic life history traits are unknown. Recreation and travel impacts on herpetofauna in general and specifically here in Montana, have been little studied. The following is a list of some of the information that is most needed.

1. Accurate and extensive distribution data on all species known to inhabit the state.
2. Determination of whether or not the following species are present in the state:
   - Idaho Giant Salamander (*Dicamptodon aterrimus*)
   - Canadian Toad (*Bufo hemiophrys*)
   - Wood Frog (*Rana sylvatica*)
   - Great Basin Spadefoot (*Scaphiopus intermontanas*)
   - Pygmy Short-horned Lizard (*Phrynosoma douglasi*)
3. Understanding the status of all species in the state through long-term monitoring.
4. Ecology, phenology, and life history data on all species in the state.
5. Impacts of nonindigenous fishes.
6. Impacts of various piscicides used in fisheries management.
7. Distribution and effects of the exotic bullfrog (*Rana catesbeiana*).
8. Information on the presence, spread, and impacts of various pathogens.
9. Extent of road mortality for all species.
10. Extent of ORV and watercraft induced mortality.
11. Impacts of various road building and maintenance activities.
12. Impacts of water impoundments and recreational facilities.
13. Extent of commercial and recreational collecting and harvest of all species.
14. Degree and effects of contamination of waters with herbicides, pesticides, fuels, and other chemicals.
15. Extent of mortality resulting from domestic, feral, and wild animals.
16. Impacts of waterfowl and waterfowl management activities.
17. Effects of anthropogenic sources of noise and light.
18. Degree and effects of habitat fragmentation for various species.
19. Identification of mitigation techniques for all of the anthropogenic impacts mentioned.

Table 2.1 General Habitat Types and Associated Amphibian and Reptile Species in Montana

Habitat Type	Amphibians	Reptiles
Temporary ponds and wetlands in the mountainous regions of the state	- Long-toed Salamander (*Ambystoma macrodactylum*) - Boreal Toad (*Bufo boreas boreas*) - Pacific Treefrog (*Hyla regilla*) - Columbia Spotted Frog (*Rana luteiventris*)	- Western Terrestrial Garter Snake (*Thamnophis elegans*) - Common garter snake (*Thamnophis sirtalis*)
Temporary ponds and wetlands in the plains regions of the state	- Tiger Salamander (*Ambystoma tigrinum*) - Plains Spadefoot (*Scaphiopus bombifrons*) - Boreal Chorus Frog (*Pseudacris maculata*) - Great Plains Toad (*Bufo cognatus*) - Woodhouse's Toad (*Bufo woodhousei*)	- Smooth Green Snake (*Opheodrys vernalis*) - Western Terrestrial Garter Snake (*Thamnophis elegans*) - Common Garter Snake (*Thamnophis sirtalis*) - Plains Garter Snake (*Thamnophis radix*)
Permanent lakes and ponds in mountainous regions of the state	- Long-toed Salamander (*Ambystoma macrodactylum*) - Boreal Toad (*Bufo boreas boreas*) - Columbia Spotted Frog (*Rana luteiventris*) - Bullfrog (*Rana catesbeiana*) - Northern Leopard Frog (*Rana pipiens*)	- Painted Turtle (*Chrysemys picta*) - Western Terrestrial Garter Snake (*Thamnophis elegans*) - Common Garter Snake (*Thamnophis sirtalis*)
Permanent lakes and ponds in the plains regions of the state	- Tiger Salamander (*Ambystoma tigrinum*) - Canadian Toad (*Bufo hemiophrys*) - Woodhouse's Toad (*Bufo woodhousei*) - Northern Leopard Frog (*Rana pipiens*)	- Common Snapping Turtle (*Chelydra serpentina*) - Painted Turtle (*Chrysemys picta*) - Smooth Green Snake (*Opheodrys vernalis*) - Western Terrestrial Garter Snake (*Thamnophis elegans*) - Common Garter Snake (*Thamnophis sirtalis*) - Plains Garter Snake (*Thamnophis radix*)
Riverine and riparian habitats in the mountainous regions of the state	- Tailed Frog (*Ascaphus truei*) - Columbia Spotted Frog (*Rana luteiventris*)	- Painted Turtle (*Chrysemys picta*) - Rubber Boa (*Charina bottae*) - Western Terrestrial Garter Snake (*Thamnophis elegans*) - Common Garter Snake (*Thamnophis sirtalis*)
Riverine and riparian habitats in the plains regions of the state	- Woodhouse's Toad (*Bufo woodhousei*) - Northern Leopard Frog (*Rana pipiens*)	- Common Snapping Turtle (*Chelydra serpentina)* - Painted Turtle (*Chrysemys picta*) - Spiny Softshell (*Apalone spinifera*) - Western Hognose Snake (*Heterodon nasicus*) - Western Terrestrial Garter Snake (*Thamnophis elegans*) - Common Garter Snake (*Thamnophis sirtalis*) - Plains Garter Snake (*Thamnophis radix*)
Closed forest habitats in the western portion of the state	- Long-toed Salamander (*Ambystoma macrodactylum*)	- Northern Alligator Lizard (*Elgaria coerulea*) - Western Skink (*Eumeces skiltonianus*) - Rubber Boa (*Charina bottae*)
Prairie and open forest habitats in the mountainous region of the state	-	- Western Skink (*Eumeces skiltonianus*) - Racer (*Coluber constrictor*) - Bull Snake *(Pituophis catenifer*) - Western Rattlesnake (*Crotalus viridis*)
Prairies, badlands, and open forest habitats in the plains regions of the state	- Tiger Salamander (*Ambystoma tigrinum*) - Plains Spadefoot (*Scaphiopus bombifrons*) - Boreal Chorus Frog (*Pseudacris maculata*)	- Short-horned Lizard (*Phrynosoma hernandezi*) - Sagebrush Lizard (*Sceloporus graciosus*) - Racer (*Coluber constrictor*) - Western Hognose Snake (*Heterodon nasicus*) - Bull Snake (*Pituophis catenifer*) - Western Rattlesnake (*Crotalus viridis*)
Fractured rock sites near streams, springs and spray zones in the northwestern part of the state	- Coeur d'Alene Salamander (*Plethodon idahoensis*)	
Cliff and hogback habitats in the plains regions of the state		- Milk Snake (*Lampropeltis triangulum*)

LITERATURE CITED

Adams, M .J. 1997. Experimental analysis of tadpole mortality factors: effects of bullfrogs and exotic fish in the Puget Sound Lowlands, Washington. Dissertation, University of Washington, Seattle, Washington.

Ankney, C. D. 1996. An embarrassment of riches: too many geese. Journal of Wildlife Management 60:217-223.

Auiderwijk, A. 1989. Amphibians and reptile tunnels in the Netherlands. In T.E.S. Langton editor. Amphibians and roads: proceedings of the toad tunnel conference, Rendsburg, Federal Republic of Germany. Published by ACO Polymer Products Ltd., Hitching Road, Shefford, Bedfordshire, SG17 5JS, England. 202pp.

Bahls, P. 1992. The status of fish populations and management of high mountain lakes in the western United States. Northwest Science 66(3): 183-193.

Ballinger, R .E. and K. S. Watts. 1995. Path to extinction: impact of vegetational change on lizard populations on Arapaho Prairie in the Nebraska Sandhills. American Midland Naturalist 134: 413-417.

Bauerle, B., D. L. Spencer, and W. Wheeler. 1975. The use of snakes as indicator species. Copeia 1975: 366-368.

Beebee, T. J. C. 1997. Changes in dewpond numbers and amphibian diversity over 20 years on chalk downland in Sussex, England. Biological Conservation 81: 215-219.

Beebee, T. J. C., R. J. Flower, A. C. Stevenson, S. T. Patrick, P. G. Appleby, C. Fletcher, C. Marsh, J. Natkanski, B. Rippey, and R. W. Battarbee. 1990. Decline of the natterjack toad *Bufo calamita* in Britain: palaeoecological, documentary and experimental evidence for breeding site acidification. Biological Conservation 53: 1-20.

Berger, L., R. Speare, P. Daszak, D. E. Green, A. A. Cunningham, C. L. Goggin, R. Slocombe, M. A. Ragan, A. D. Hyatt, K. R. McDonald, H. B. Hines, K. R. Lips, G. Marantelli, and H. Parkes. 1998. Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. Proceedings of the National Academy of Sciences 95: 9031-9036.

Bergeron, J. M., D. Crews, and J. A. McLachlan. 1994. PCBs as environmental estrogens: turtle sex determination as a biomarker of environmental contamination. Environmental Health Perspectives 102: 780-781.

Bernardino, F. S., Jr., and G. H. Dalrymple. 1992. Seasonal activity and road mortality of the snakes of the Pa-hay-okee wetlands of Everglades National Park, USA. Biological Conservation 62: 71-75.

Berrill, M., S. Bertram, A. Wilson, S. Louis, D. Brigham, and C. Stromberg. 1993. Lethal and sublethal impacts of pyrethroid insecticides on amphibian embryos and tadpoles. Environmental Toxicology and Chemistry 12(3): 525-539.

Berrill, M., S. Bertram, L. McGillivray, M. Kolohon, and B. Paul. 1994. Effects of low concentrations of forest-use pesticides on frog embryos and tadpoles. Environmental Toxicology and Chemistry 13(4): 657-664.

Birdsall, C. W., C. E. Grye, and A. Anderson. 1986. Lead concentrations in bullfrog *Rana catesbeiana* and green frog *R. clamitans* tadpoles inhabiting highway drainages. Environmental Pollution A. 40: 233-247.

Black, J. H. 1969a. Yes--there are bullfrogs in Montana. Montana Outdoors 1969: 4.

Black, J. H. 1969b. The frog genus *Rana* in Montana. Northwest Science 43(4): 191-195.

Black, J. H. 1981. Oklahoma rattlesnake hunts --1981. Bulletin of the Oklahoma Herpetological Society 6: 39-43.

Blaustein, A. R. 1993. Declining amphibian populations in perspective. Park Science 1993(Fall): 8-9.

Blaustein, A. R. 1994. Chicken little or Nero's fiddle: a perspective on declining amphibian populations. Herpetologica 50: 85-87.

Blaustein, A.R., and D.B. Wake. 1990. Declining amphibian populations a global phenomenon? Trends in Ecology and Evolution 5: 203-204

Blaustein, A. R., P. D. Hoffman, D. G. Hokit, J. M. Kiesecker, S. C. Walls, and J. B. Hays. 1994a. UV repair and resistance to solar UV-B in amphibian eggs: a link to population declines? Proceedings of the National Academy of Sciences 91: 1791-1795.

Blaustein, A. R., D. G. Hokit, and R. K. O'Hara. 1994b. Pathogenic fungus contributes to amphibian losses in the pacific northwest. Biological Conservation 67:251-254.

Blaustein, A. R., B. Edmond, J. M. Kiesecker, J. J. Beatty, and D. G. Hokit. 1995. Ambient ultraviolet radiation causes mortality in salamander eggs. Ecological Applications 5: 740-743.

Boarman W., and M. Sazaki. 1996. Highway mortality in desert tortoises and small vertebrates: Success of barrier fences and culverts. Pages 169-173 *in* Evink G., D. Ziegler, P. Garrett, and J. Berry, editors. Highways and movement of wildlife: Improving habitat connections and wildlife passageways across highway corridors. Proceedings of the Florida Department of Transportation/Federal Highway Administration Transportation-Related Wildlife Mortality Seminar [April 30-May 2, 1996, Orlando, Florida].

Bondello, M.C. 1976. The effects of high intensity motorcycle sounds on the acoustical sensitivity of the desert iguana, *Dipsosaurus dorsalis* Masters Thesis, California State University, Fullerton, California.

Boyer, R., and C. E. Grue. 1995. The need for water quality criteria for frogs. Environmental Health Perspectives 103: 352-357.

Bradford, D. F. 1983. Winterkill, oxygen relations, and energy metabolism of a submerged dormant amphibian, *Rana muscosa*. Ecology 64: 1171-1183.

Bradford, D. F. 1989. Allotropic distribution of native frogs and introduced fishes in high Sierra Nevada lakes of California: Implication of the negative effect of fish introductions. Copeia 1989: 775-778.

Bradford, D. F., F. Tabatabai, and D. M. Graber. 1993. Isolation of remaining populations of the native frog, *Rana muscosa*, by introduced fishes in Sequoia and Kings Canyon National Parks, California. Conservation Biology 7: 882-888.

Brana, F., L. Frechilla, and G. Orizaola. 1996. Effect of introduced fish on amphibian assemblages in mountain lakes of northern Spain. Herpetological Journal 6: 145-148.

Branch, L. C., D. G. Hokit, and B. M. Stith. 1996. Landscape dynamics and Florida scrub lizards: assessing the effects of landscape structure on populations at multiple scales. Final report, RWO 122, Biological Resources Division, U.S. Department of Interior, Washington, D.C., USA.

Brattstrom, B. H., and M. C. Bondello. 1979. The effects of dune buggy sounds on the telencephalic auditory evoked response in the Mojave fringe-toed lizard, *Uma scoparia* Unpublished Report to U.S. Bureau of Land Management, California Desert Program, Riverside, California. 31pp. Contract CA-060-CT7-2737.

Bronmark, C., and P. Edenhamn. 1994. Does the presence of fish affect the distribution of tree frogs (*Hyla arborea*)? Conservation Biology 8(3): 841-845

Buchanan, B. W. 1993. Effects of enhanced lighting on the behavior of nocturnal frogs. Animal Behaviour 45: 893-899.

Buck, S. V. 1997. Florida's Herp trade: a collector's paradise and a land exploited. Reptile and Amphibian Magazine. Jan/Feb. 1997: 72-81.

Burton, T. M., and G. E. Likens. 1975a. Salamander populations and biomass in the Hubbard Brook Experimental Forest, New Hampshire. Copeia 1975: 541-546.

Burton, T. M., and G. E. Likens. 1975b. Energy flow and nutrient cycling in salamander populations in the Hubbard Brook Experimental Forest, New Hampshire. Ecology 56: 1068-1080.

Bury, R. B., and J. A. Whelan. 1984. Ecology and management of the bullfrog. USFWS Resource Publication 155: 1-23.

Bury, R. B., C. K. Dodd, Jr., and G. M. Fellers. 1980. Conservation of the amphibia of the United States: a review. Department of the Interior, Fish and Wildlife Service Publication Number 134: 1-34, Washington, D.C., USA.

Bury, R. B., R. A. Luckenbach, and S. O. Busack. 1977. Effects of off-road vehicles on vertebrates in the California Desert. Washington, D.C. U.S. Fish and Wildlife Service. Wildlife Research Report 8: 1-23.

Busack, S. D., and R. B. Bury. 1974. Some effects of off-road vehicles and sheep grazing on lizard populations in the Mojave Desert. Biological Conservation 6(3):179-83.

Bush, B., R. Browne-Cooper, and B. Maryan. 1991. Some suggestions to decrease reptile roadkills in reserves with emphasis on the western Australian wheatbelt. Herpetofauna 21(2): 23-24.

Campbell, H. 1956. Snakes found dead on the roads of New Mexico. Copeia 1956: 124-125.

Campbell, J. A., D. R. Formanowicz, Jr., and E. D. Brodie, Jr. 1989. Potential impact of rattlesnake roundups on natural populations. Texas Journal of Science 41: 301-317.

Carey, C. 1993. Hypothesis concerning the causes of the disappearance of Boreal toads from the mountains of Colorado. Conservation Biology 7(2): 355-362.

Carey, C., and Bryant, C. J. 1995. Possible interrelations among environmental toxicants, amphibian development, and decline of amphibian populations. Environmental Health Perspectives 103 (Suppl. 4): 13-17.

Carpenter, H. L., and E. O. Morrison. 1973. Feeding behavior of the bullfrog, *Rana catesbeiana*, in north central Texas. Bios 44: 188-193.

Christiansen, J. L., and B. J. Gallaway. 1984. Raccoon removal, nesting success, and hatchling emergence in Iowa turtles with special reference to *Kinosternon flavescens* (Kinosternidae). Southwestern Naturalist 29: 343-348.

Clark, V. S. 1991. A report on rattlesnake roundups in Oklahoma and other parts of the United States. Herpetology 21: 12-15.

Clarkson, R. W., and J. C. DeVos, Jr. 1986. The bullfrog, *Rana catesbeiana* Shaw, in the lower Colorado River, Arizona, California. Journal of Herpetology 20: 42-49.

Coman, B. J., and H. Brunner. 1972. Food habits of the feral house cat in Victoria. Journal of Wildlife Management 36: 848-853.

Congdon, J. D., A. E. Dunham, and R. C. van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's turtles (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. Conservation Biology 7(4): 826-833.

Congdon, J. D., A. E. Dunham, and R. C. van Loben Sels. 1994. Demographics of common snapping turtles (*Chelydra serpentina*): implications for conservation and management of long-lived organisms. American Zoologist 34: 397-408.

Cooke, A. K. 1981. Tadpoles as indicators of harmful levels of pollution in the field. Environmental Pollution (Series A) 25: 123-133.

Cooper, C. M., P.C. Smiley, Jr., J. D. Wigginton, S. S. Knight, and K.W. Kallies. 1998. Vertebrate use of habitats created by installation of field-scale erosion control structures. Journal of Freshwater Ecology 12(2): 199-207.

Corn, J., and P. Hendricks. 1998. Lee Metcalf National Wildlife Refuge bullfrog and painted turtle investigations: 1997. Montana Natural Heritage Program. Helena, MT. 20pp.

Corn, P. S. 1994. What we know and don't know about amphibian declines in the west. Pages 59-67 *in* W. Covington and L. DeBano (technical coordinators.), Sustainable ecological systems: implementing an ecological approach to land management. U.S.D.A. Forest Service, Rocky Mountain Forest and Range Experimental Station, Ft. Collins, Colorado. General Technical Report RM-247.

Corn, P. S., W. Stolzenburg, and R. B. Bury. 1989. Acid precipitation studies in Colorado and Wyoming: interim report of surveys of montane amphibians and water chemistry. Biological Report 80(40.26). Air Pollution and Acid Rain Report No. 26. 57pp.

Court, E. L. 1997. Lupus anticoagulants: pathogenesis and laboratory diagnosis. British Journal of Biomedical Science 54(4): 287-298.

Daugherty, C. H., and A. L. Sheldon. 1982. Age specific movement patterns of the frog *Ascaphus truei*. Herpetologica 38(4): 468-474.

Dean, J. N., J. L. Glenn, and R. C. Straight. 1980. Bilateral cleft labial and palate in the progeny of a *Crotalus viridis viridis* Rafinesque. Herpetological Review 11(4): 91-92.

Demaynadier, P. G., and M. L. Hunter. 1998. Effects of silvicultural edges on the distribution and abundance of amphibians in Maine. Conservation Biology 12:340-352.

Denney, R. N. 1974. The impact of uncontrolled dogs on wildlife and livestock. Pages 257-291 *in* Transactions of the 39th North American Wildlife and Natural Resources Conference.

Dickman, M. 1968. The effect of grazing by tadpoles on the structure of a periphyton community. Ecology 49: 1188-1190.

Dodd, C. K., Jr. 1988. Disease and population declines in the flattened musk turtle *Sternotherus depressus*. American Midland Naturalist 119(2): 394-401.

Dodd, C. K., Jr. 1990. Effects of habitat fragmentation a stream-dwelling species, the flattened musk turtle *Sternotherus depressus*. Biological Conservation 54:33-45.

Dodd, C. K., Jr. 1996. Use of terrestrial habitats by amphibians in the sandhill uplands of north-central Florida. Alytes 14: 42-52.

Dodd, C. K., Jr. and B. S. Cade. 1998. Movement patterns and the conservation of amphibians breeding in small, temporary wetlands. Conservation Biology 12(2): 331-339.

Dodd, C. K. Jr., K. M. Enge and J. N. Stuart. 1989. Reptiles on highways in north-central Alabama, USA. Journal of Herpetology 23: 197-200.

Dole, J. W. 1965. Summer movement of adult leopard frogs, *Rana pipiens* Schreber, in northern Michigan. Ecology 46: 236-255.

Drost, C. A., and G. M. Fellers. 1996. Collapse of a regional frog fauna in the Yosemite area of the California Sierra Nevada, USA. Conservation Biology 10: 414-425.

Duellman, W. E., and L. Trueb. 1986. Biology of amphibians. Johns Hopkins University Press, Baltimore, Maryland, USA.

Dunson, W. A., R. L. Wyman, and E. S. Corbett. 1992. A symposium on amphibian declines and habitat acidification. Journal of Herpetology 26(4): 349-442.

Ehmann, H. and H. G. Cogger. 1985. Australia's endangered herpetofauna: a review of criteria and policies. Pages 435-447. In: G. Grigg, R. Shine, and H. Ehmann (eds.) The biology of Australasian frogs and reptiles. Surrey Beatty and Sons, Sydney.

Ehrlich, D. 1979. Predation by bullfrog tadpoles (*Rana catesbeiana*) on eggs and newly hatched larvae of the plains leopard frog (*Rana blairi*). Bulletin of the Maryland Herpetological Society 15: 25-26.

Elton, C. S. 1958. The ecology of invasions by animals and plants. Methuen, London, England.

Ernst, C. H., R. W. Barbour, and J. E. Lovich. 1994. Turtles of the United States and Canada. Smithsonian Institution Press. Washington D.C. 578pp.

Ewert, M. A. 1969. Seasonal movements of the toads Bufo americanus and *Bufo cognatus* in northwestern Minnesota. Ph.D. dissertation. University of Minnesota, St. Paul, Minnesota. 193pp.

Fahrig, L. 1998. Relative effects of habitat loss and fragmentation on population extinction. Journal of Wildlife Management 61(3): 603-610.

Fahrig, L., and G. Merriam. 1994. Conservation of fragmented populations. Conservation Biology 8:50-59.

Fahrig, L., J. H. Pedlar, S. E. Pope, P. D. Taylor, and J. F. Wegner. 1995. Effect of road traffic on amphibian density. Biological Conservation 73(3): 177-182.

Figiel, C. R., Jr., and R. D. Semlitsch. 1990. Population variation in survival and metamorphosis of larval salamanders (*Ambystoma maculatum*) in the presence and absence of fish predation. Copeia 1990: 818-826.

Fisher, R. N., and H. B. Shaffer. 1996. The decline of amphibians in California's Great Central Valley. Conservation Biology 10(5): 1387-1397.

Fontenot, L. W., G. P. Noblet, and S. G. Platt. 1994. Rotenone hazards to amphibians and reptiles. Herpetological Review 25(4): 150-156.

Fowle, S. C. 1996. The painted turtle in the Mission Valley of western Montana. M.S. thesis, University of Montana. Missoula, Montana. 101pp.

Fuller, P. L., L. G. Nico, and J. D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. American Fisheries Society Special Publication 27.

Gamradt, S. C., and L. B. Kats. 1996. Effect of introduced crayfish and mosquitofish on California newts. Conservation Biology 10: 1155-1162.

Garber, S. D., and J. Burger. 1995. A 20-yr study documenting the relationship between turtle decline and human recreation. Ecological Applications 5(4): 1151-1162.

Gendron, A. D., C. A. Bishop, R. Fortin, and A. Hontela. 1997. In vivo testing of the functional integrity of the corticosterone-producing axis in mudpuppy (Amphibia) exposed to chlorinated hydrocarbons in the wild. Environmental Toxicology and Chemistry 16(8): 1694-1706.

Germano, D. J., and C. R. Hungerford. 1981. Reptile population changes with manipulation of Sonoran Desert shrub. Great Basin Naturalist 41: 129-138.

Gibbons, J. W., and M. E. Dorcas. 1998. Cowards, bluffers, and warriors: what does it take to make a cottonmouth strike? Natural History 107(9): 56-57.

Gloyd, H. K. 1933. An unusual feeding record for the prairie rattlesnake. Copeia 1933(2): 98.

Greene, H. W. 1997. Snakes: the evolution of mystery and nature. University of California Press, Berkeley, California.

Gregory, P. T., and K. W. Stewart. 1975. Long-distance dispersal and feeding strategy of the red-sided garter snake (*Thamnophis sirtalis parietalis*) in the interlake of Manitoba. Canadian Journal of Zoology 53: 238-245.

Griffiths, R. A., J. Denton, and A. L. C. Wong. 1993. The effect of food level on competition in tadpoles: interference mediated protothecan algae? Journal of Animal Ecology 62: 274-279.

Gulve, P. S. 1994. Distribution and extinction patterns within a northern metapopulation of the pool frog, *Rana lessonae*. Ecology 75(5): 1357-1367.

Grover, M. C., and L. A. DeFalco. 1995. Desert tortoise (*Gopherus agassizii*): status-of-knowledge outline with references. General Technical Report INT-GTR-316. U.S. Forest Service, Intermountain Research Station, Ogden, Utah.

Guillette, L. J., Jr., T. S. Gross, G. R. Masson, J. M. Matter, H. F. Percival, and A. R. Woodward. 1994. Developmental abnormalities of the gonad and abnormal sex hormone concentrations in juvenile alligators from contaminated and control lakes in Florida. Environmental Health Perspectives 102: 680-688.

Hailman, J. P. 1982. Extremely low ambient light levels of *Ascaphus truei*. Journal of Herpetology 16: 83-84.

Hall, R. J., and D. R. Clark, Jr. 1982. Responses of the iguanid lizard *Anolis carolinensis* to four organophosphorus pesticides. Environmental Pollution (Series A): 28: 45-52.

Hall, R. J., and P. F. P. Henry. 1992. Assessing effects of pesticides on amphibians and reptiles: status and needs. Herpetological Journal 2: 65-71.

Hammerson, G. A. 1982. Bullfrog eliminating leopard frogs in Colorado? Herpetological Review 13: 115-116.

Hanski, I., and M. Gilpin. 1991. Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linaean Society 42: 3-16.

Harfenist, A., T. Power, K. L. Clark, and D. B. Peakall. 1989. A review and evaluation of the amphibian toxicological literature. Canadian Wildlife Service Technical Report Series 61. Canadian Wildlife Service, Ottawa, Canada. 222pp.

Hart, M. M., W. A. Williams, P. C. Thornton, K. P. McLaughlin, C. M. Tobalske, B. A. Maxell, D. P. Hendricks, C. R. Peterson, and R. L. Redmond. 1998. Montana atlas of terrestrial vertebrates. Montana Cooperative Wildlife Research Unit, The University of Montana. Missoula, Montana vii + 1302pp.

Hecnar, S. J., and R. T. M'Closkey. 1996. Regional dynamics and the status of amphibians. Ecology 77: 2091-2097.

Hecnar, S. J., and R. T. M'Closkey. 1997*a*. The effects of predatory fish on amphibian species richness and distribution. Biological Conservation 79: 123-131.

Henderson, R. W. 1992. Consequences of predator introductions and habitat destruction on amphibians and reptiles in the post-Columbus West Indies. Caribbean Journal of Science 28(1-2): 1-10.

Hendricks, P., and J. D. Reichel. 1996. Preliminary amphibian and reptile survey of the Ashland District, Custer National Forest: 1995. Montana Natural Heritage Program. Helena, Montana. 79pp.

Hockin, D. C., K. O'Hara, D. Cragg-Hine, and J. W. Eaton. 1985. Fish population estimation: the use of rotenone to evaluate the reliability of a removal technique. Aquaculture and Fisheries Management 16: 349-357.

Hokit, D. G., B. M. Stith, and L. C. Branch. 1999. Effects of landscape structure in Florida scrub: a population perspective. Ecological Applications 9:124-134.

Hopey, M. E., and J. W. Petranka. 1994. Restriction of wood frogs to fish-free habitats: how important is adult choice? Copeia 1994: 1023-1025.

Hopkins, W. A., M. T. Mendona, and J. D. Congdon. 1997. Increased circulating levels of testosterone and corticosterone in southern toads, *Bufo terrestris*, exposed to coal combustion waste. General Comparative Endocrinology 108: 237-246.

Huckabee, J. W., C. P. Goodyear, and R. D. Jones. 1975. Acid rock in the Great Smokies: unanticipated impact on aquatic biota of road construction in regions of sulfide mineralization. Transactions of the American Fisheries Society 4:677-684.

Iverson, J. B. 1978. The impact of feral cats and dogs on populations of the West Indian rock iguana, *Cyclura carinata*. Biological Conservation 14: 63-73.

Jackson, S. D., and T. F. Tyning. 1989. Effectiveness of drift fences and tunnels for moving spotted salamanders *Ambystoma maculatum* under roads. In T. E. S. Langton editor. Amphibians and roads: proceedings of the toad tunnel conference, Rendsburg, Federal Republic of Germany. Published by ACO Polymer Products Ltd., Hitchin Road, Shefford, Bedfordshire, SG17 5JS, England. 202pp.

Jennings, M. R., and M. P. Hayes. 1985. Pre-1900 overharvest of California red-legged frogs (*Rana aurora draytoni*): the inducement for bullfrog (*Rana catesbeiana*) introduction. Herpetologica 41: 94-103.

Jennings, M. R., D. F. Bradford, and D. F. Johnson. 1992. Dependence of the garter snake *Thamnophis elegans* on amphibians in the Sierra Nevada of California. Journal of Herpetology 26: 503-505.

Johnson, C. R., and J. E. Prine. 1976. The effects of sublethal concentrations of organophosphorus insecticides and an insect growth regulator on temperature tolerance in hydrated and dehydrated juvenile western toads, *Bufo boreas*. Comparative Biochemistry and Physiology 53A:147-149.

Jordan, D. S. 1891. A reconnaissance of the streams and lakes of Yellowstone National Park, Wyoming. The American Angler 21(2), November 1891.

Kerbes, R. H., P. M. Kotanen, and R. J. Jefferies. 1990. Destruction of wetland habitats by lesser snow geese: a keystone species on the west coast of Hudson Bay. Journal of Applied Ecology 27:242-258.

Kiesecker, J. M. 1997. The effects of pathogens, UV-B radiation, and introduced species on amphibians in the Pacific Northwest. Ph.D. dissertation, Oregon State University. Corvallis, OR. 194pp.

Kiesecker, J. M., and A. R. Blaustein. 1995. Synergism between UV-B radiation and a pathogen magnifies amphibian embryo mortality in nature. Proceedings of the National Academy of Sciences 92: 11049-11052.

Kiesecker, J. M., and A. R. Blaustein. 1997*a*. Influences of egg laying behavior on pathogenic infection of amphibian eggs. Conservation Biology 11: 214-220.

Kiesecker, J. M., and A. R. Blaustein. 1997*b*. Population differences in responses of red-legged frogs (*Rana aurora*) to introduced bullfrogs. Ecology 78: 1752-1760.

Kiesecker, J. M., and A. R. Blaustein. 1998. Effects of introduced bullfrogs and smallmouth bass on microhabitat use, growth, and survival of native red-legged frogs (*Rana aurora*). Conservation Biology 12: 776-787.

King, M. B. 1990. Prairie rattlesnake seasonal migrations: episodes of movement, vernal foraging, and sex differences. Animal Behaviour 39: 924-935.

Kirk, J. J. 1988. Western spotted frog (*Rana pretiosa*) mortality following forest spraying of DDT. Herpetological Review 19(3): 51-53.

Knapp, R. A. 1996. Non-native trout in natural lakes of the Sierra Nevada: an analysis of their distribution and impacts on native aquatic biota. Pages 363-406 *in* Sierra Nevada ecosystem project: final report to Congress, volume III, assessments, commissioned reports, and background information. University of California Centers for Water and Wildland Resources, Wildland Resources Center Report 38, Davis, California.

Koch, E. D., and C. R. Peterson. 1995. The amphibians and reptiles of Yellowstone and Grand Teton National Parks. University of Utah Press. Salt Lake City, Utah. 188pp.

Koch, E. D., G. Williams, C. R. Peterson, and P. S. Corn. 1996. Conference on declining and sensitive amphibians in the Northern Rockies and the Pacific Northwest: a summary paper. Idaho Herpetological Society Technical Bulletin and U.S. Fish and Wildlife Service Report, Boise, Idaho.

Korschgen, L. J., and T. S. Baskett. 1963. Foods of impoundment and stream dwelling bullfrogs in Missouri. Herpetologica 19: 88-99.

Kucken, D. J., J. S. Davis, J. W. Petranka, and C. K. Smith. 1994. Anakeesta Stream acidification and metal contamination - effects on a salamander community. Journal of Environmental Quality 23(6): 1311-1317.

Kupferberg, S. J. 1994. Exotic larval bullfrogs (*Rana catesbeiana*) as prey for native garter snakes: functional and conservation implications. Herpetological Review 25(3): 95-97.

Kupferberg, S. J. 1996. The ecology of native tadpoles (*Rana boylii* and *Hyla regilla*) and the impact of invading bullfrogs (*Rana catesbeiana*) in a northern California river. Ph.D. dissertation, University of California at Berkeley, Berkeley, California. 289pp.

Kupferberg, S. J. 1997. Bullfrog (*Rana catesbeiana*) invasion of a California river: the role of larval competition. Ecology 78: 1736-1751.

Laan, R., and B. Verboom. 1990. Effects of pool size and isolation on amphibian communities. Biological Conservation 54:251-262.

Langley, W. M., H. W. Lipps, and J. F. Theis. 1989. Responses of Kansas motorists to snake models on a rural highway. Transactions of the Kansas Academy of Science 92(1-2) 43-48.

Langton, T. E. S. (ed.). 1989. Amphibians and Roads. Proceedings of the toad tunnel conference. Rendsburg, Federal Republic of Germany, 7-8 January 1989. ACO Polymer Products, Shefford Bedfordshire, United Kingdom. 202pp.

Lathan, A., O. Linda, and S.L. Staggers. 1996. Ancrod: The use of snake venom in the treatment of patients with heparin-induced thrombocytopenia and thrombosis undergoing coronary artery bypass grafting. Heart and Lung 25(6): 451-460.

Laurance, W. F., K. R. McDonald, and R. Speare. 1996. Epidemic disease and the catastrophic decline of Australian rain forest frogs. Conservation Biology 10:406-413.

Lawler, S. P., D. Dritz, T. Strange, and M. Holyoak. 1999. Effects of introduced mosquitofish and bullfrogs on the threatened California red-legged frog. Conservation Biology 13(3): 613-622.

Lehtinen, R. M., S. M. Galatowitsch, and J. R. Tester. 1999. Consequences of habitat loss and fragmentation for wetland amphibian assemblages. Wetlands 19(1): 1-12.

Lefcort, H., R. A. Meguire, L. H. Wilson, and W. F. Ettinger. 1998. Heavy metals alter the survival, growth, metamorphosis, and antipredatory behavior of Columbia spotted frog (*Rana luteiventris*) tadpoles. Archives of Environmental Contaminants and Toxicology 35: 447-456.

Lewis, D. L., G. T. Baxter, K. M. Johnson, and M. D. Stone. 1985. Possible extinction of the Wyoming toad, *Bufo hemiophrys baxteri*. Journal of Herpetology 19: 166-168.

Licht, L. E. 1969. Palatability of Rana and Hyla eggs. American Midland Naturalist 82: 296-298.

Lind, A. J., H. H. Welsh, Jr., and R. A. Wilson. 1996. The effects of a dam on breeding habitat and egg survival of the Foothill Yellow-legged frog (*Rana boylii*) in Northwestern California. Herpetological Review 27(2): 62-67.

Liss, W. J., and G. L. Larson. 1991. Ecological effects of stocked trout on North Cascades naturally fishless lakes. Park Science 11: 22-23.

Lips, K. R. 1999. Mass mortality and population declines of anurans at an upland site in Western Panama. Conservation Biology 13: 117-125.

Lodge, D. M. 1993. Biological invasions: lessons for ecology. Trends in Ecology and Evolution 8: 133-137.

MacArthur, R. H., and E. O. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton, New Jersey. 203pp.

Mahaney, P. A. 1994. Effects of freshwater petroleum contamination on amphibian hatching and metamorphosis. Environmental Toxicology and Chemistry 13(2):259-265.

Maniero, G. D., and C. Carey. 1997. Changes in selected aspects of immune function in the leopard frog, *Rana pipiens*, associated with exposure to cold. Journal of Comparative Physiology 167:256-263.

Manny, B. A., W. C. Johnson, and R. G. Wetzel. 1994. Nutrient additions by waterfowl to lakes and reservoirs: predicting their effects on productivity and water quality. Hydrobiologia 279/280:121-132.

Margules, C. R., G. A. Milkovitts, and G. T. Smith. 1994. Contrasting effects of habitat fragmentation on the scorpion *Cercophonius squama* and an amphipod. Ecology 5: 2033-2042.

Marsh, D. M., and P. B. Pearman. 1997. Effects of habitat fragmentation on the abundance of two species of leptodactylid frogs in an Andean montane forest. Conservation Biology 11:1323-1328.

Mathews, A. E. 1989. Conflict, controversy, and compromise: the Concho water snake (*Nerodia harteri paucimaculata*) versus the Stacy Dam and Reservoir. Environmental Management 13(3): 297-307.

Maxell, B. A., P. S. Corn, P. Hendricks, T. Koch, C. Peterson, and K. Werner. 1998. Brief overview of boreal toad status in USFS Region 1. Unpublished report. 8pp.

Maxell, B. A. In Press. Distribution and status of amphibians and reptiles in Montana. Abstract to be published in the Intermountain Journal of Sciences. Presented at the Montana Chapter of the American Fisheries Society Meetings, Big Sky, Montana. February 5th, 1999.

Maxell, B. A., J. K. Werner, and D. P. Hendricks. In Review. Herpetology in Montana: A history, species checklist, species accounts, dot distribution maps, museum records, and indexed bibliography. To be submitted to the Society for Northwestern Vertebrate Biology for publication as a Northwestern Fauna occasional monograph on vertebrate natural history.

McAuliffe, J. R. 1978. Seasonal migrational movements of a population of the western painted turtle, *Chrysemys picta bellii* (Reptilia, Testudines, Testudinae). Journal of Herpetology 12(2): 143-149.

McCoid, M. J., and P. W. Bettoli. 1996. Additional evidence for rotenone hazards to turtles and amphibians. Herpetological Review 27(2): 70-71.

McMurry, F. B., and C. C. Sperry. 1941. Food of feral house cats in Oklahoma, a progress report. Journal of Mammalogy 22(2): 185-190.

Morin P. J. 1983. Predation, competition, and the composition of larval anuran guilds. Ecological Monographs 53: 119-138.

Moyle, P. B. 1973. Effects of introduced bullfrogs, *Rana catesbeiana* on the native frogs of the San Joaquin Valley, California. Copeia 1973(1): 18-22.

Nace, G. W., and J. K. Rosen. 1979. Source of amphibians for research II. Herpetological Review 10: 8-15.

Nagl, A. M., and R. Hofer. 1997. Effects of ultraviolet radiation on early larval stages of the Alpine newt, *Triturus alpestris*, under natural and laboratory conditions. Oecologia 110: 514-519.

Nash, R. F., G. G. Gallup, Jr., and M. K. McClure. 1970. The immobility reaction in leopard frogs (*Rana pipiens*) as a function of noise-induced fear. Psychonometric. Science 21(3): 155-156.

Nico, L. G., and P. L. Fuller. 1999. Spatial and temporal patterns of nonindigenous fish introductions in the United States. Fisheries 24(1): 16-27.

Nussbaum, R. A., E. D. Brodie, Jr., and R. M. Storm. 1983. Amphibians and reptiles of the Pacific Northwest. University of Idaho Press. Moscow, Idaho. 332pp.

Nyman, S. 1986. Mass mortality in larval *Rana sylvatica* attributable to the bacterium, *Aeromonas hydrophila*. Journal of Herpetology 20:196-201.

Olson, D. H. 1989. Predation on breeding Western toads (*Bufo boreas*). Copeia 1989(2):391-397.

Olson, D. H. 1992. Ecological susceptibility of amphibians to population declines. Pages 55-62 *in* R. R. Harris, D. E. Erman (technical Coordinators) and H. M. Kerner (editors). Proceedings of symposium on biodiversity of northwestern California. University of California Wildland Resources Center, Report 29, Davis, California.

Parmalee, P. W. 1953. Food habits of the feral house cat in east-central Texas. Journal of Wildlife Management 17(3): 375-376.

Patla, D. A. 1997. Changes in a population of spotted frogs in Yellowstone National Park between 1953 and 1995: the effects of habitat modification. M.S. thesis, Idaho State University, Pocatello, Idaho. 215pp.

Patla, D. A. 1998. Potential effects of native fish restoration projects on amphibians in Yellowstone National Park Part I. Report to National Park Service, Yellowstone National Park. 20 November 1998. 26pp.

Pechmann, J. K., and H. M. Wilbur. 1994. Putting declining amphibian populations in perspective: natural fluctuations and human impacts. Herpetologica 50(1): 65-84.

Petranka, J. W. 1989. Chemical interference competition in tadpoles: does it occur outside laboratory aquaria? Copeia 1989: 921-930.

Petranka, J. W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington D. C. 587pp.

Phillips, K. 1990. Where have all the frogs and toads gone? Bioscience 40: 422-424.

Pimental, D. 1971. Ecological effects of pesticides on non-target organisms. U.S. Government Printing Office, Washington D.C. 220pp.

Porter, K. R., and D. E. Hakanson. 1976. Toxicity of mine drainage to embryonic and larval boreal toads (Bufonidae: *Bufo boreas*). Copeia 1976: 327-331.

Post, D. M., J. P. Taylor, J. F. Kitchell, M. H. Olson, D. E. Schindler, and B. R. Herwig. 1998. The role of migratory waterfowl as nutrient vectors in a managed wetland. Conservation Biology 12:910-920.

Pough, F. H. 1980. The advantages of ectothermy for tetrapods. American Naturalist 115: 92-112.

Pough, F. H. 1983. Amphibians and reptiles as low-energy systems. Pages 141-188 in Behavioral Energetics: the cost of survival in vertebrates. Ohio State University Press. Columbus, Ohio.

Pough, F. H., R. M. Andrews, J. E. Cadle, M. L. Crump, A. H. Savitzky, and K. D. Wells. 1998. Herpetology. Prentice-Hall Inc., Upper Saddle River, New Jersey. 577pp.

Pounds, J. A., and M. L. Crump. 1994. Amphibian declines and climate disturbance: the case of the golden toad and harlequin frog. Conservation Biology 8(1): 72-85.

Pounds, J. A., M. P. L. Fogden, and J. H. Campbell. 1999. Biological response to climate change on a tropical mountain. Nature 398: 611-615.

Prior, K. A., and P. Weatherhead. 1994. Response of free-ranging eastern Massasauga rattlesnakes to human disturbance. Journal of Herpetology 28(2): 255-257.

Rauscher, R. L. 1998. Amphibian and reptile survey on selected Montana Bureau of Reclamation impoundments. Montana Department of Fish, Wildlife and Parks, Nongame Program. Bozeman, Montana. 24pp.

Redmond, R. L., M. M. Hart, J. C. Winne, W. A. Williams, P. C. Thornton, Z. Ma, C. M. Tobalske, M. M. Thornton, K. P. McLaughlin, T. P. Tady, F. B. Fisher, and S. W. Running. 1998. The Montana gap analysis project: final report. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, Montana. xiii + 136pp. + appendices.

Reichel, J. D. 1995. Preliminary amphibian and reptile survey of the Sioux District of the Custer National Forest: 1994. Montana Natural Heritage Program. Helena, Montana. 75pp.

Reichel, J. D., and D. L. Flath. 1995. Identification guide to the amphibians and reptiles of Montana. Montana Outdoors 26(3): 15-34.

Reinking, L. N., C. H. Daugherty, and L. B. Daugherty. 1980. Plasma aldosterone concentrations in wild and captive western spotted frogs (*Rana pretiosa*). Comparative Biochemistry and Physiology 65A(4): 517-518.

Resetarits, W. J., Jr., and H. M. Wilbur. 1989. Choice of oviposition site by *Hyla chrysoscelis*: role of predators and competitors. Ecology 70: 220-228.

Reynolds, W. L. 1979. Response of reptile populations to different land management practices on the Idaho National Engineering Laboratory Site. Great Basin Naturalist 39: 255-262.

Robinson, G. R., R. D. Holt, M. S. Gaines, S. P. Hamburg, M. J. Johnson, H. S. Fitch, and E. A. Martinko. 1992. Diverse and contrasting effects of habitat fragmentation. Science 257: 524-526.

Roedel, M. D., and D. P. Hendricks. 1998. Amphibian and reptile survey on the Bureau of Land Management Lewistown District: 1995 - 1998. Montana Natural Heritage Program. Helena, Montana. 53pp.

Rosen, P. C., and C. H. Lowe. 1994. Highway mortality of snakes in the Sonoran desert of southern Arizona. Biological Conservation 68: 143-148.

Rosen, P. C., C. R. Schwalbe, D. A. Parizek Jr., P. A. Holm, and C. H. Lowe. 1995. Introduced aquatic vertebrates in Chiricahua region: effects on declining native ranid frogs. U.S. Forest Service General Technical Report RM 264: 251-261.

Rowe, C. L., O. M. Kinney, and J. D. Congdon. 1998. Oral deformities in tadpoles of the bullfrog (*Rana catesbeiana*) caused by conditions in a polluted habitat. Copeia 1998(1): 244-246.

Russell, R. W., S. J. Hecnar, and G. D. Haffner. 1995. Organochlorine pesticide residues in southern Ontario spring peepers. Environmental Toxicology and Chemistry 14: 815-817.

Saunders, H. O. 1970. Pesticide toxicities to tadpoles of the western chorus frog, *Pseudacris triseriata*, and Fowler's toad, *Bufo woodhousei fowleri*. Copeia 1970(2): 246-251.

Schaaf, R. T., and J. S. Garton. 1970. Raccoon predation on the American toad, *Bufo americanus*. Herpetologica 26: 334-335.

Schnick, R. A. 1974. A review of the literature on use of rotenone in fisheries. U.S. Fish and Wildlife Service, Literature Review 74-15. No. PB-235 454/AS. 130pp.
Schwalbe, C. R. 1993. Status of amphibians in Arizona. Park Science 1993(Fall): 10.
Scott, N. J., Jr. 1996. Evolution and management of the North American grassland herpetofauna. Pages 40-53 *in* D. M. Finch editor. Ecosystem disturbance and wildlife conservation in western grasslands: a symposium proceedings. General Technical Report RM-GTR-285. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
Seale, D. B. 1980. Influence of amphibian larvae on primary production, nutrient flux, and competition in a pond ecosystem. Ecology 61: 1531-1550.
Semlitsch, R. D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding salamanders. Conservation Biology 12:1113-1119.
Semlitsch, R. D., and J. W. Gibbons. 1988. Fish predation in size-structured populations of treefrog tadpoles. Oecologia 75: 321-326.
Sexton, O. J., and C. Phillips. 1986. A qualitative study of fish-amphibian interactions in 3 Missouri ponds. Transactions of the Missouri Academy of Science 20: 25-35.
Simberloff, S. S. 1993. Effects of fragmentation on some Florida ecosystems, and how to redress them. In D. A. Saunders, R. J. Hobbs, and P. R. Erlich, editors. Nature Conservation 3. Reconstruction of fragmented ecosystems, global and regional perspectives. Surrey Beatty and Sons, Chipping Norton, New South Wales, Australia.
Sinsch, U. 1990. Migration and orientation in anuran amphibians. Ethology Ecology and Evolution 2: 65-79.
Sjögren, P. 1991. Extinction and isolation gradients in metapopulations: the case of the pool frog (*Rana lessonae*). Biological Journal of the Linnean society 42:135-147.
Sjögren-Gulve, P., and C. Ray. 1996. Using logistic regression to model metapopulation dynamics: large-scale forestry extirpates the pool frog. Pages 111-137 *in* D.R. McCullough editor. Metapopulations and wildlife conservation. Island Press, Washington D.C., USA.
Skelly, D. K. 1992. Field evidence for a cost of behavioral antipredator response in a larval amphibian. Ecology 73: 704-708.
Soulé, M. E. 1990. The onslaught of alien species, and other challenges in the coming decades. Conservation Biology 4: 233-239.
Stebbins, R. C., and N. W. Cohen. 1995. A natural history of amphibians. Princeton University Press, Princeton, New Jersey. 316pp.
Stewart, M. M. 1995. Climate driven population fluctuations in rain forest frogs. Journal of Herpetology 29(3): 437-446.
Sweet, W. T. 1953. Rattlesnake roundup. Montana Wildlife 3(2): 27-28. Montana Fish and Game Department.
Trikha, M., Y. A. De Clerck, and F. S. Markland. 1994. Contortrostatin, a snake venom disintegrin, inhibits beta-1 integrin-mediated human metastatic melanoma cell adhesion and blocks experimental metastasis. Cancer Research 54(18): 4993-4998.
Turner, F. B. 1957. The ecology and morphology of *Rana pretiosa pretiosa* in Yellowstone Park, Wyoming. Ph.D. dissertation, University of California, Berkeley, California. 252pp.
Turner, F. B., P. A. Medica, and B. W. Kowalewsky. 1976. Energy utilization by a desert lizard (*Uta stansburiana*). US/IBP Desert Biome Monograph No. 1. Utah State University Press, Logan, Utah.
Tyler, T. J., W. J. Liss, R. L. Hoffman, and L. M. Ganio. 1998*b*. Experimental analysis of trout effects on survival, growth, and habitat use of two species of ambystomatid salamanders. Journal of Herpetology 32(3): 345-349.
Van Gelder, J. J. 1973. A quantitative approach to the mortality resulting from traffic in a population of *Bufo bufo* L. Oecologia 13: 93-95.
Van Rooy, P. T. J. C., and A. H. P. Stumpel. 1995. Ecological impacts of economic development on Sardinian Herpetofauna. Conservation Biology 9(2): 263-269.
Vos, C. C., and A. H. P. Stumpel. 1995. Comparison of habitat-isolation parameters in relation to fragmented distribution patterns in the tree frog (*Hyla arborea*). Landscape Ecology 11:203-214.
Vos, C. C., and J. P. Chardon. 1998. Effects of habitat fragmentation and road density on the distribution pattern of the moor frog *Rana arvalis*. Journal of Applied Ecology 35: 44-56.
Wake, D. B. 1991. Declining amphibian populations. Science 253: 860.
Wake, D. B., and H. Morowitz. 1990. Declining amphibian populations - a global phenomena? Workshop sponsored by Board on Biology, National Research Council. Irvine, California.

Warwick, C. 1990. Disturbance of natural habitats arising from rattlesnake round-ups. Environmental Conservation 17: 172-174.
Weir, J. 1992. The Sweetwater rattlesnake round-up: A case study in environmental ethics. Conservation Biology 6: 116-127.
Welsh, H. H., Jr., and L. M. Ollivier. 1998. Stream amphibians as indicators of ecosystem stress: a case study from California's redwoods. Ecological Applications 8(4): 1118-1132.
Werner, E. E. 1992. Competitive interactions between wood frog and northern leopard frog larvae: the influence of size and activity. Copeia 1992: 26-35.
Werner, J. K., and J. D. Reichel. 1994. Amphibian and reptile survey of the Kootenai National Forest: 1994. Montana Natural Heritage Program, Helena, Montana. 104pp.
Werner, J. K., T. Plummer, and J. Weaslehead. 1998. Amphibians and reptiles of the Flathead Indian Reservation. Intermountain Journal of Sciences 4(1-2): 33-49.
Weygoldt, P. 1989. Changes in the composition of mountain stream frog communities in the Atlantic Mountains of Brazil: frogs as indicators of environmental deteriorations? Studies on Neotropical Fauna and Environment 243: 249-255.
Wilbur, H. M. 1980. Complex life cycles. Annual Review of Ecology and Systematics 11: 67-93.Wilbur, H.M. 1997. Experimental ecology of food webs: complex systems in temporary ponds. Ecology 78(8): 2279-2302.
Wilbur, H. M., P. J. Morin, and R. N. Harris. 1983. Salamander predation and the structure of experimental communities and anuran responses. Ecology 64: 1423-1429.
Wilkinson, T. 1996*a*. Utah ushers its frogs toward oblivion. High Country News, No. 19: 1, 10-13. May 27, 1996.
Wilkinson, T. 1996*b*. Reptile rustlers. National Parks 1996 (November/December): 36-39.
Wilson, E. O., and F.M. Peter (editors) 1988. Biodiversity. National Academy Press, Washington, DC. 521 p.
Worthylake, K. M., and P. Hovingh. 1989. Mass mortality of salamanders (*Ambystoma tigrinum*) by bacteria (*Acinetobacter*) in an oligotrophic seepage mountain lake. Great Basin Naturalist 49:364-372.
Wyman, R. L. 1990. What's happening to the amphibians? Conservation Biology 4(4): 350-352.
Yanes, M., J. M. Velasco, and F. Suarez. 1995. Permeability of roads and railways to vertebrates: the importance of culverts. Biological Conservation 71(3): 217-222.

CHAPTER 3

BIRDS

EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE
A Review for Montana

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MONTANA CHAPTER OF THE WILDLIFE SOCIETY

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ABSTRACT

Avian species represent a varied collection of organisms with key roles in ecological systems. Species are not immune to overall declines in biodiversity and large-scale efforts are underway to conserve bird species. Direct and indirect impacts of human recreational activities were reviewed in the literature. Avian species reacted differently to the presence of recreationists. A continuum of responses existed with habituation at one extreme and habitat abandonment at the other. Reactions varied within a species, depending on breeding status, activity (foraging, roosting etc), species size, and group size. Birds responded to human activity by altering their behavior, spatial distribution and use of habitats. Effects on breeding birds during incubation included nest desertion and temporary nest abandonment, which resulted in exposure of the eggs to temperature extremes and predators. Disturbance during brood rearing can result in trampling of eggs or neonates, premature fledging, and separation of young from parents. Outside of the breeding season, bird activity is focused on energy gain for winter and migration. Human disturbance during this period may cause changes in foraging habits and decreased foraging efficiency. Management recommendations and guidelines were presented for species groups. Birds that were endangered, threatened, or of special concern were given special attention to assist managers in prioritizing conservation strategies.

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Not everything that counts can be counted and not everything that can be counted counts.
~~ Albert Einstein ~~

INTRODUCTION

Montana's diverse geography, ecology, and climate provide habitats for a wide variety of avifauna. Records have been collected for 394 species in the state, of which 25% (n = 99) were considered rare species (MBDC 1996). Two hundred and forty-eight species of birds breed in Montana; 151 overwinter. Montana provides habitat for 2 endangered species (whooping crane, interior least tern), 2 threatened species (bald eagle, piping plover), and several species that are of special concern to federal and state agencies and private organizations (Appendix B). Declines have been attributed, in part, to: (1) fragmentation of prairie habitats due to agricultural developments and human population growth; (2) river impoundments, channelization, and levee construction; (3) human disturbance; and (4) pesticide use.

Land-use practices in Montana have changed drastically in the last century and have contributed to changing abundance and distribution of bird species. Some species, such as the European starling or brown-headed cowbird, thrive in human-altered landscapes and have expanded their ranges to become dominant residents of Montana's landscape. Other species, such as the piping plover, require specific habitats that are relatively undisturbed, and become rare or threatened when human development occurs in these areas (MBDC 1996).

Species react differently to the presence of people. Several birds habituate to people and cease responding as intensively or as frequently as they did in the past. Reactions can vary within a species depending on breeding status, activity (e.g., foraging, roosting), species size, location (interior species versus edge species), and group sizes (Burger et al. 1995). Because outdoor enthusiasts rarely view themselves as having a degrading effect on the environment, special management activities are needed to ensure that avian biodiversity is maintained.

This chapter was developed to identify species that may suffer negative impacts from recreational activities, both motorized and non-motorized, and to suggest management procedures for Montana agencies, organizations, and private landowners. Papers, dissertations and theses, bulletins and articles originating nationwide were reviewed in an effort to identify potential threats to Montana's avian species. Avian species in this chapter were grouped into one or more of the following categories for discussion: (1) waterfowl; (2) gulls, waders, and fish-eating birds; (3) gallinaceous birds; (4) birds of prey; (5) woodpeckers and cavity-nesters; and (6) songbirds. Included in several of the sections are paragraphs highlighting the needs of "featured species" (i.e., Species of Special Concern, threatened, endangered, proposed and sensitive species). Management recommendations for each group are presented at the end of each subsection.

WATERFOWL

There are 37 species of waterfowl in Montana, 23 of which breed in at least part of the state (MBDC 1996). Much of the following information is from Korschgen and Dahlgren (1992) unless otherwise noted. They reviewed 21 journal articles on human disturbance of waterfowl to compile what is known. In the last 20 years, the intensity of water-based recreation has increased drastically. Waterfowl are wary, seeking refuge from all forms of disturbance, particularly those associated with loud noise and rapid movement.

Activities that cause disturbance are listed in order of decreasing severity: (1) rapid overwater movement and loud noise; (2) overwater movement with little noise such as sailing, wind-surfing, rowing, or canoeing; (3) little overwater movement or noise such as wading or swimming; and (4) activities along shorelines such as fishing, birdwatching, hiking, and traffic.

<u>Effects on Breeding Waterfowl</u>

Effects on breeding waterfowl include several components of reproduction, including; declining numbers of breeding pairs, increased desertion of nests, reduced hatching success, and decreased duckling survival. Human disturbance can reduce several of these components and, over time, result in declining waterfowl populations.

Disturbance can result in declining numbers of breeding pairs. Disturbance during critical times of the nesting cycle eventually causes ducks to nest elsewhere or not at all. In Maine, American black ducks (*Anas rubripes*) and ring-necked ducks (*Aythya collaris*) did not nest under conditions of excessive human disturbance. mallards (*Anas platyrhynchos*) at the Seney National Wildlife Refuge in Michigan failed to nest in areas open to fishing. Some Wisconsin lakes bordered by homes were so heavily used for recreation that breeding ducks did not use otherwise suitable habitat. In Germany, an 85% decrease of the breeding stock of ducks at 2 small ponds presumably was caused solely by an increasing number of anglers during the waterfowl-breeding season. Numbers of mallards, green-winged teals (*Anas crecca*), northern shovelers (*Anas clypeata*), pochards, and tufted ducks decreased from 26 pairs to 4 pairs during an 8-year period. Human activity on nesting islands can cause desertion or predation of waterfowl nests.

Studies of several species of waterfowl identified human disturbance as the cause of desertions or abandonment of nests, especially during early incubation. Disturbance from observers caused a 10% nest abandonment rate by mallards using artificial nest baskets in an Iowa study. Frequent visits to goose nests by biologists caused nest desertion rates as high as 40%. Canada geese (*Branta canadensis*) nesting in southeastern Missouri were very sensitive to persons fishing in their nesting areas. Establishing areas closed to fishing during the nesting period decreased nest desertions.

Human disturbance has three basic effects on hatching success: (1) flushing of hens off nests may expose eggs to heat or cold and kill embryos; (2) flushing of hens off nests may increases egg depredation and (3) creating trails or leaving markers near nests may increase predator density and subsequent egg and hen depredation. When nests of cackling Canada geese were checked several times before hatch, twice the number of eggs were lost to predators. Where human activities disturbed Canada geese or common eiders (*Somateria mollissima*) that were nesting among black-backed gulls (*Larus marinus*), herring gulls (*Larus argentatus*), or parasitic jaegers (*Stercorarius parasiticus*) on islands or in tundra colonies, the gulls and jaegers often quickly located and consumed eggs in waterfowl nests unoccupied because of human disturbance.

Disturbance by humans during the brood-rearing season can break up and scatter broods or frighten parents into running ahead of their ducklings or goslings. Young waterfowl briefly separated from their mother are vulnerable to predators and susceptible to death from severe weather or lack of experience in obtaining food. Disturbances drastically increase kills of Common Eider ducklings by gulls. For example, the number of eider ducklings killed by gulls in Sweden was 200-300 times greater when broods were disturbed by boats than when they remained undisturbed. In northern Maine, American black duck and ring-necked duck broods averaged 2 fewer ducklings because of mortality from disturbance by motorboats. Human disturbance caused a higher than normal mortality rate of trumpeter swan (*Cygnus buccinator*) cygnets in a study area in Alaska. Human disturbance can also have direct effects on waterfowl; water skiers and powerboats have run over white-winged scoter (*Melanitta fusca*) hens and broods, and some boaters have used paddles to kill ducklings.

Effects on Nonbreeding Waterfowl

Migratory and wintering waterfowl generally attempt to minimize time spent in flight and maximize foraging time. Flight requires considerably more energy than any other activity; except egg-laying. Human disturbance compels waterfowl to change food habits, feed only at night, lose weight, or desert the feeding area. Waterfowl respond to loud noises and rapid movements, such as boats powered by outboard motors, and to visible features, such as sailboats. Large flocks are more susceptible to disturbances than small flocks.

Not all waterfowl species are equally sensitive to disturbance, and some may habituate to certain disturbances. In Europe, pink-footed geese were disturbed at a distance of 500 m when more than 20 cars per day used a road in the fall. Traffic (as few as 10 cars per day) also had a depressing effect on habitat use by geese. Thus, the surrounding buffer area must exceed 500 m to render habitat acceptable to flocks of pink-footed geese. Some waterfowl, especially diving ducks [e.g., canvasbacks (*Aythya valisineria*), redheads (*Aythya americana*)] are especially vulnerable to disturbance. Density and patterns of disturbance may influence diving ducks more than dabbling ducks in most areas. Repeated disturbances also can deny birds access to preferred feeding habitats. Diving duck use of several good feeding areas along the upper Mississippi River was limited primarily by boating disturbances that caused 90% of the waterfowl to concentrate on 28% of the study area during daytime.

In the absence of disturbance, brants in Great Britain spent an average of 1.1% of their time in flight, but disturbance on weekends caused the time spent in flight to increase as much as sevenfold and prevented brants from feeding for up to 11.7% of the time. Detailed studies are few, but observations suggest that the effects of intensive recreation during the fall and winter could be deleterious to migrating and wintering waterfowl.

Researchers who attempted to quantify the harm from disturbances to migrating and wintering waterfowl indicated that frequency of disturbance, number of affected birds, and changes in behavior are greater than most suspected. For example, each duck and American coot on Houghton Lake, Michigan, was disturbed on the average of 1.5 times per weekday and more than 2 times during weekend days. On Navigation Pool 7 of the upper Mississippi River, an average of 17.2 boats passed through the study area each day and resulted in 5.2 disturbances per day and a minimum of more than 4 minutes of additional flight time per disturbance (Korschgen et al. 1985). Over 2,500 tundra swans (*Cygnus columbianus*) left their most important feeding area on the upper Mississippi River in response to two small boats.

Prolonged and extensive disturbances may cause large numbers of waterfowl to leave disturbed wetlands and migrate elsewhere. These movements can be local in areas of plentiful habitat or more distant and permanent in areas of sparse habitat, and may result in shifts in flyway migration patterns. Extensive disturbances on migration and wintering areas may limit use by waterfowl below the carrying capacity of wetlands. Daily disturbances by boaters may have been responsible for eliminating the brant population that once spent November and December on Humbolt Bay, California.

Featured Species: Clark's Grebe

Clark's grebe (*Aechmophorus clarkii*) is a summer resident of Montana, breeding on freshwater lakes and marshes with extensive areas of open water bordered by emergent vegetation. When approached by humans, birds often cover the nest with material and abandon the site; overheating of eggs may result on hot, sunny days. Parents and small chicks on lakes frequently become separated when parents dive to avoid motor boats or other sources of disturbance. The result is death from overexposure or increased predation (Storer and Neuchterlein 1992).

Featured Species: Harlequin Duck

Harlequin ducks (*Histrionicus histrionicus*) winter on the coast and fly inland to low-gradient streams in western Montana to breed. Because their breeding habitats differ significantly from other waterfowl and because they are listed as a sensitive species, they will be discussed in more detail here.

Studies have repeatedly shown that harlequin ducks are very sensitive to human disturbance in breeding territories. Ashley (1994) found that birds used inaccessible stream habitats more than expected based on availability of these habitats. In Grand Teton National Park, 95% of harlequin observations were in backcountry areas accessible only by trail (Wallen 1987). In Yellowstone National Park, a 3-year study was done to assess visitor impacts to habitat used by harlequins at LeHardy Rapids, where it appeared that duck use had decreased due to high visitor use (McEneaney 1994). The area was closed to visitors from May 1 to June 7 1991-1993, and duck use increased; however, a historical nest site in the immediate vicinity was not reoccupied.

Wallen (1987) reported that fishing seemed more disruptive to harlequins than hiking. Birds avoided humans on the bank or in the streambed and would typically swim or dive downstream past people, remaining partially submerged and watchful while moving out of the area. Fishing has also had some direct effects on harlequins. Birds have been found entangled in fishing line in Glacier National Park on McDonald Creek (Ashley 1994) and in Jasper National Park on Maligne Lake (Clarkson 1992). A duck has also been found with a fishhook lodged in its throat (F. Cassirer, Biologist, Idaho Dept. of Fish and Game, personal communication).

Commercial whitewater rafting in Jasper National Park has frequently exposed pre-nesting and perhaps nesting ducks to disturbance (Clarkson 1992, Hunt 1993). Only 6 commercial trips took place in 1986; 1,500 commercial trips were completed in 1990. The rise in commercial-trip occurrence was significantly correlated with harlequin duck declines during the period 1986-92 (Hunt 1993).

Featured Species: Trumpeter Swan

The trumpeter swan is listed as a sensitive species. Although recovery efforts have increased swan numbers, historic migratory paths have not yet been restored. As a result, many breeding swans in the Greater Yellowstone Ecosystem (GYE) and Canada share the same high-elevation winter habitat in GYE, where geothermal features keep water open through the winter. Management efforts have been focused on protecting and enhancing nesting and wintering habitat (Clark et al. 1989).

Breeding trumpeter swans responded differently to different types of disturbance stimuli. Swan behavior was not affected by vehicle traffic on the Copper River highway as long as vehicles did not stop. In Yellowstone National Park, trumpeters nested within 200 m of a busy highway, but were alerted when vehicles stopped and passengers emerged (Henson and Grant 1991).

Featured Species: Common Loon

Montana has the only significant common loon (*Gavia immer*) population in the continental United States west of the Mississippi River. Approximately 200 loons are found north of Missoula and west of the Continental Divide. In this population, about 65 breeding pairs have been identified. Of these, 24-26 pair will successfully raise 1-2 chicks each year. Approximately 85% of the breeding pairs in Montana are found in Montana Fish, Wildlife and Parks (MFWP)-Region 1. The U.S. Forest Service in Region 1 listed the loon as a sensitive species in 1986.

Recent continent-wide studies of banded loons by David Evers and Peter Reaman of BioDiversity Research Institute in Maine revealed many factors of loon biology that were previously unknown but are vital for proper management of this species. The mean first age of breeding is 7 years (range: 5-10 years). The birds are thought to live 25-30 years, however there are no banded bird studies to verify this. Juveniles leave their natal lakes in the fall for an unknown coastal area where they stay for 2.5 years. They return to the natal lake or adjacent areas as 3-year -old black-and-white adults. Maximum-dispersal distance from the natal lake is 65 km but is more often 11-16 km depending on topography and lake/territory availability. These birds are poor pioneers of new areas and are slow to actually claim their own territory. Across North America, 80% of birds returned to their partners and territories. Adult mortality rate is 3-5%. Recruitment rate for juveniles is optimistically estimated at 30%, however, the actual rate is probably closer to 20%. Usually 33-35 chicks are raised in northwest Montana, which, based on the 30% recruitment rate, means that 11-12 black -and -white adults will return to natal lakes 3 years later. Twenty to forty percent of a loon population should consist of single birds that can replace lost breeders.

The management implications of these data are that nesting pairs should be protected to increase nest success and recruitment. Banded loons (n=15) in Montana nest on lakes that are larger than 5.4 ha in size and below 1491 m in elevation (Skaar1989). Preferred nest sites are islands in protected parts of a lake such as inlets, outlets, and shallow marshy backwater areas shielded from wind and wave actions. The nesting islands are usually vegetated with at least 1.5-3 m of water at the edge of the nest. Nursery areas are in shallow marshy backwaters with abundant insect and small fish populations for feeding rapidly growing chicks up to 4 weeks of age. Nursery areas are protected from wind and wave action and are found near the nest.

Loons arrive in Montana during April and spend the next 2-4 weeks becoming reacquainted during a quiet courtship period. Anecdotal observations indicate that the nesting area should be free from consistent disturbance during this time so that the birds can select a nest site. One or 2 goose-sized eggs are laid, and the 26-29 day incubation period begins between May 1 – May 20. Kelly (1992) found that 60% of nest departures were caused by some kind of human activity with 51% of these disturbances involving boats. Average time off the nests due to human activities was 24 minutes, which was significantly longer than the 8 minutes observed for flushes resulting from natural or “non-human" causes. Kelly (1992) also found that loons left the nest at 140, 130, 100, and 70 m during the first, second, third, and fourth weeks of incubation respectively, in response to approaching boats. On the basis of this information, mitigation for recreational activities was appropriate. The term “recreational activity" referred primarily to the presence of any type of boat, ranging from canoes and fishing boats to ski boats and personal watercraft, that ventured near nest sites or family units.

Management of common loons in Montana has been ongoing since 1989. Two major management components have been employed: (1) closures around nest sites delineated by floating signs; (2) education of recreationists at public boat ramps, campgrounds, public meetings, and classrooms. The number of successful nests, number of chicks, and the number of 2-chick broods have significantly increased with use of protective floating signs (Kelly 1992). We recommend Kelly (1992) for an excellent description of detailed management techniques; we provide a condensed version here. Location of nests should be ascertained as quickly as possible after nest initiation, and locations of previously successful nests should be closely monitored because loons tend to reuse sites (Strong 1987). Birds are most sensitive to boat presence during the first 2 weeks of incubation, and delay of nesting caused by increased recreation early in May can predispose the nest to failure (Yonge 1981, Heimberger et al. 1983). Set floating signs 70-150 m from nests. Maintain flexibility in sign location and avoid, when possible, closure of traditional boat-travel routes. If public pressure is not too great on the lakes, wait until loons are actually brooding before placing signs. Caution should be used on lakes in the Clearwater drainage and in some areas of the Tobacco-Stillwater drainage where heavy recreational traffic may warrant placing signs around a suspected nest area before actual initiation of a nest.

Correct placement of floating signs may impact the effectiveness of the signing program. Nests along the shoreline should have a minimum of 5 signs arranged in a semicircle 70-150 m from the nest site. The two signs nearest the shoreline should be within 60-90 m of land so that canoes hugging the shorelines see and heed the signs. Island nests require at least 6 signs encircling the entire island. If the island is large enough, the signs on the side of the island opposite the nest can be much closer to the island than the signs on the side where the nest is.

Personal contact with the recreating public improves compliance and is best accomplished by meeting recreationists at public boat ramps and individual campsites. Quickly explain that there are loon signs on the lake and their purpose, inserting a few facts about the loon population and its requirements.

Regulatory efforts to control recreational boating activity involve implementing and enforcing “no-wake” zones or motor restrictions. While these types of regulatory efforts should be used only as a last resort, managers should be aware that growth of recreational activity and shoreline development on lakes in northwest Montana will probably warrant widespread implementation of these measures within the next 10 years. Public education efforts should continue as regulations go into effect so that recreationists will understand the purpose.

Managers may want to consider consistent enforcement of regulations across lakes rather than maintaining unique regulations for each lake. At this time, there have not been any formal studies quantifying impacts of personal watercraft (PWC) on nesting success and chick-rearing. Incidental observations and anecdotal reports suggest personal watercraft do impact loons in Montana. Increased numbers of tremolos (alarm calls) have been heard as PWC enter loon territories even at a distance of approximately 200 m or more. Tremolos were normally not heard in response to fishing boats until the vehicles were within an estimated 50 m of a family unit (with a chick present). Floating signs set at 100-150 m did not appear to keep loons in the Clearwater drainage on their nests when PWCs were present. Managers should consider taking extra precautions if frequent PWC use occurs during May when nesting is occurring or near nursery areas during June.

Fishing derbies and tournaments for northern pike and bass can potentially increase loon disturbance because these fish species are found in the same shallow backwater habitats as loon nests. Managers should place signs around potential nesting areas to decrease disturbance during nest-site selection. Tournaments should not be allowed on lakes where loon nesting occurs until after June 20 when the birds should be off the nest. If very young chicks (up to 3 weeks old) are present and if the loons have remained in a defined nursery area near the nest, then the signs should remain in place in order to protect the family unit from continual disturbance throughout the tournament.

Loss of nesting areas due to development of shoreline is a very serious threat to the continuation of successful loon reproduction in Montana. Heimberger et al. (1983) noted that hatching success declined as the number of cottages within 150 m of the nest increased. P. D. Skaar (Montana State University, unpublished data) found that loons did not nest on lakes under 20 ha unless at least half of the shoreline was undisturbed by houses and roads, and activity on the lake surface from anglers and boaters was low. Exceptionally high- or low- water years force loons to build nests in secondary locations; shoreline development limits nest-location options so that loons cannot respond to environmental or weather conditions as easily. Managers should identify present and potential nest sites in northwest Montana and protect them from encroachment of development.

There is concern about genetic isolation of the Montana loon population from Canadian populations, and isolation of loons in the Clearwater drainage (MFWP Region 2) from loons in Region 1. Given the biological vulnerability of this bird, every breeding pair and every chick should be considered important to the Montana population; thus, managers should not disregard pairs that have nested in “problem" areas.

Both lead and mercury poisoning have been identified as causing deaths of individual loons. Mercury has been implicated as a contributor in nest failures. Lead poisoning, from ingestion of fishing sinkers, has been identified as the cause of death for half of the dead loons necropsied in New England studies (Pokras et al. 1992). Nationwide, the highest mercury levels were found in New England and Canada where levels were high enough to cause disruption of nesting and death of individual birds. Levels in Montana loons were low and within the normal range (Evers and Reaman, unpublished data).

<u>Overall Management Guidelines for Montana Waterfowl</u>

Fortunately, numbers of breeding waterfowl usually increase in response to reduction or elimination of human disturbances. For the benefit of waterfowl, human disturbances must be minimized or eliminated. Management techniques that reduce human disturbances of waterfowl include:

1. Increasing the quantity, quality, and distribution of foods to compensate for energetic costs from disturbances.

2. Establishing screened buffer zones around important waterfowl breeding, roosting and feeding areas.

3. Reducing the number of roads and access points to limit accessibility to important waterfowl habitats.

4. Reducing the sources of loud noises and rapid movements of vehicles and machines.

5. Locating wildlife-viewing areas >300 m from trumpeter swan nests, and hiding viewing areas in vegetation to minimize noise and visibility of users.

6. Closing stream sections where harlequin ducks are known to breed, especially while the chicks are flightless (June to early August) (Clark et al. 1989).

7. Monitoring loon-nesting areas; increasing information and educational materials provided to recreationists.
8.

GULLS, WADERS, AND FISH-EATING BIRDS

Pelicans, cormorants, herons, bitterns, rails, plovers, sandpipers, American avocets (*Recurvirostra americana*), stilts, gulls, terns, and cranes are considered in this section. Based on information from Montana Bird Distribution (1996), this group includes 83 species; 22 are found in Montana only during the breeding season, 8 yearlong, 46 on occasion, and 7 during winter only. Because the breeding season is an especially critical time for many species, the emphasis of this section is on summer recreation. However, areas of concentrated use during spring and fall migrations can be important and general guidelines are provided for this time period as well.

<u>Colony nesters</u>

Many seabirds, gulls, and waders that breed in Montana are colony nesters including gulls, terns, great blue herons (*Ardea herodias*), black-crowned night herons (*Nycticorax nycticorax*), snowy egrets (*Egretta thula*), white-faced ibis (*Plegadis chihi*), double-crested cormorants (*Phalacrocorax auritus*) and American white pelicans (*Pelecanus erythrorhynchos*). Historically, colony nesters have been intentionally killed either for their feathers or because the were thought to compete with fishermen. Indirectly, habitat loss, alteration and disturbance have also affected them. Colonial-breeding bird species are particularly sensitive to disturbance (Tremblay and Ellison 1979, Vos et al. 1985). Human activity can cause adults to flush from their nests; this increases the probability of egg or nestling mortality from exposure (i.e., heat stress, cold stress, or overexposure from being submerged), trampling or predation, nest desertion, or premature departure from the nest by young. In extreme cases, there may be displacement of the colony to less suitable habitats, reduced productivity (because they fail to renest), or complete colony abandonment (Vos et al. 1985). Indirect effects of recreational use have included embedded lures in young pelicans and entanglement with fishing lines (Johnson 1976).

The distance at which individuals in nesting colonies are flushed may depend on: (1) sensitivity of each nesting species to disturbance; (2) timing of disturbance with respect to the breeding season; and (3) the degree to which birds have acclimated to human activity (Tremblay and Ellison 1979, Erwin 1989). Breeding terns studied in New Jersey (Burger 1997) showed the strongest response to personal watercraft, racing boats, and boats travelling outside the established channel. Vos et al. (1985) reported that herons habituated to repeated, non-threatening activities such as fishing. A great-blue heron rookery located next to a service road with truck traffic was active for more than 20 years (Anderson 1978). Herons studied at Ding Darling NWR in Florida habituated to areas of high human activity (Klein, et al. 1995).

Non-colonial species

Several Montana species breed and nest in riparian areas, shorelines and wetlands [soras (*Porzana carolina*), rails, American avocets, piping plovers (*Charadrius melodus*), spotted sandpipers (*Actitis macularia*), phalaropes (*Phalaropus* sp.), cranes (*Grus* sp.), gulls and terns] or on upland sites (plovers, upland sandpipers). Several of these breeders are sensitive to human disturbance. Secretive rails depend on dense cover for protection from disturbance and predation. Human activities that affect shoreline vegetation (i.e., fishing) can affect breeding habitat for these species. Documented impacts of high-speed water boating include shoreline degradation, disruption of nesting and feeding areas with loss of production of young and displacement of water birds (Braun et al. 1978). Direct effects of ORVs include stress and death (when nests or young are driven over). Long-billed curlews (*Numenius americanus*) nest in short-grass areas adjacent to water or wet meadows; repeated disturbance in these habitats can cause nest abandonment.

Featured Species: Mountain Plover

Mountain plovers (*Charadrius montanus*) have shown a widespread decline and are currently being considered for listing as threatened by the US Fish and Wildlife Service (USFWS). Plovers breed in areas of good visibility, usually short-grass prairie with bare ground. In Montana, prairie dog towns appear to be providing “islands" of habitat within areas not otherwise suitable for nesting. Unfortunately, prairie dog towns have drastically declined due to changes in land uses, widespread poisoning of colonies, recreational shooting, and spread of Sylvatic plague. Maintenance of these towns is crucial to maintaining breeding populations of mountain plovers in Montana (Olson and Edge 1985). Recreational shooting of prairie dogs may indirectly affect mountain plovers. When humans intrude into nest areas, adults perform distraction displays. In one case, 1 adult died of stress-related causes (Graul 1975). In addition to disturbance, off-road driving has resulted in vehicle routes through nesting habitat (Werschler 1991).

Featured Species: Piping Plover

Piping plovers (*Charadrius melodus*), a threatened species, are sensitive to the presence of humans and their pets, especially on islands and rivers where recreational beach activities can displace nesting plovers. Piping plovers nest on shoreline beaches, having areas of clumped vegetation and large areas of barren gravel beaches. Territories with evidence of motor vehicle (OHV) disturbance showed lower nest success than undisturbed areas (Gaines and Ryan 1988, Strauss 1990).

Another study in Nova Scotia (Flemming et al. 1988) found that disturbance resulted in fewer chicks surviving to 17 days. Disturbed chicks exhibited decreased feeding and brooding time and increased sitting and vigilance. When feeding did occur, it was at a reduced rate. By altering chick behavior, disturbance may have caused increased chick mortality and subsequently contributed to declining numbers in Nova Scotia. These same effects were also observed for adults and chicks in a study on the coast of New Jersey (Burger 1991) and in another study on beaches of Cape Cod (Strauss 1990).

Featured Species: Interior Least Tern

Interior least terns can be found in eastern Montana along the Yellowstone and Missouri rivers during the breeding season. Nesting habitat is open, flat, sand or pebble beaches along rivers and reservoirs. Sandbars, islands, and man-made structures (i.e., dikes, sandpits, flyash lagoons) have also been used as nest sites. Population declines of this endangered species have been attributed to loss of breeding habitat and human disturbance, especially during the nesting season (late May to early July). Reel et al. (1989) reported that human disturbance forced adults off their nests, leaving eggs or young vulnerable to predation and overexposure.

Featured Species: Whooping Crane

Whooping cranes (*Grus americana*) are endangered and currently occupy only a fraction of their historic range. Birds use Montana habitats adjacent to Yellowstone National Park and the Centennial Valley during migration to and from breeding grounds. These areas are primarily shallow wetlands, wet meadows, and adjacent uplands. Cranes tolerate little human disturbance, especially during the breeding season (May to mid-August). Minimal human disturbance is often sufficient to cause abandonment of nests (Clark et al. 1989).

Migratory Shorebirds

Of the 83 species of gulls, seabirds and wading birds found in Montana, more than half of them use Montana habitats as stop-over sites during migration. Other species that breed here have fall staging areas, which are important conditioning areas. For example, body mass of adult sandhill cranes increased an average of 17-20% from early September to late October (Krapu and Johnson 1990). Very little information exists about the effects of recreation on these species in inland areas. The effects of recreation on migrant shorebirds have been studied on the East Coast (Burger et al. 1995, Deblinger et al. 1991). Indirect effects include reduced foraging time due to displacement and reduced food supply due to compaction of the sand. Studies at Ding Darling NWR found that shorebirds were displaced more than 60 m from roads and 80 m from walking routes by human visitation (Klein et al. 1995).

Management Guidelines

1. Implement interpretive/educational programs (e.g., lectures, tours, leaflets, exhibits, signs, and press releases) about nesting colonies.

2. Limit motorized use to designated routes where traffic is not allowed to stop.

3. Restrict foot travel and pets within 300 m of active colonies. Colony boundaries should be clearly posted with signs (informational and regulatory). Remove signs as soon as colonies are no longer active (Buckley and Buckley 1978).

4. Use the following guidelines to create buffers:
   - pelican and cormorant colonies: restrict access within 1,000 m from April 15 to September 15 (Markham and Brechtel 1978)
   - great blue heron colonies: restrict access within 250 m on land and 150 m on water (Vos et al. 1985); Markham and Brechtel (1978) recommended 0.5 km from April 15 to September 15.
   - wading-bird colonies and terns: restrict access within 100 m terns; 180 m for mixed species and ground-nesting species (Rodgers and Smith 1995).
   - island-nesting colonies: restrict access within 50 m (Anderson 1978)

5. Restrict research at heron rookeries until a week before hatching begins. Visits should not be more frequent than every 3-4 days until young are about 3 weeks old. No visits should be made in inclement weather (Tremblay and Ellison 1979).

6. Make shorebird-migration-staging areas “disturbance-free" during periods of use (Morrison and Harrington 1979).

7. Reduce negative effects of tourists by using guided tours and low-disturbance zones where people stay in their cars. Reduce the number of visitors or close the road on certain days during the busy season (Klein et al. 1995).

8. Limit off-road travel in mountain plover nesting habitat during the nesting season (April to early July) (Wershler 1991).

9. Promote research to assess impacts of recreation on waders, gulls, and shorebirds in the western United States, especially shorebirds in the Rocky Mountains.

UPLAND GAME

There are several species of upland game birds in Montana including forest grouse [blue grouse (*Dendragapus obscurus*), ruffed (*Bonasa umbellus*), spruce grouse (*Dendragapus canadensis*)], shrubland grouse [sage grouse (*Centrocercus urophasianus*) and sharp-tailed grouse (*Tympanuchus phasianellus*)], white-tailed ptarmigan (*Lagopus leucurus*), and introduced species such as ring-necked pheasants (*Phasianus colchicus*), chukar partridge (*Alectoris chukar*), and wild turkeys (*Meleagris gallopavo*). Our focus is on shrubland species because they are known to be sensitive to habitat changes, have concentrated breeding sites (leks), and sensitive species status. Turkeys are specifically addressed because they are a popular, hunted species.

Featured Species: Sage and Columbian Sharp-tailed Grouse

Numerous factors have been implicated in the decline of sharp-tailed grouse, including conversion of native rangelands to cropland, excessive grazing by livestock, herbicide treatment, removal of trees in riparian zones, invasion of conifers, and urban developments and associated recreational areas. In addition, increasing use of public lands is having an impact on habitat quality (Mattise 1995). C.H. Trost (Idaho State University, pers. comm) noted that bird enthusiasts, especially bird photographers, have caused desertion of grouse leks in Idaho.

Leks are the focal point for management; disturbance of leks may result in regional declines in populations (Baydack and Hein 1987). Leks are typically adjacent to nesting and brood-rearing areas. Because approximately 50% of nesting and brood-rearing take place within 1.5 km of leks The habitat around lek areas must be protected and enhanced. Sharp-tail leks are usually found on knolls, ridgetops, high benches, or openings surrounded by sagebrush; buffers around these areas should be 2 km. Sage grouse leks are usually found in areas of sagebrush canopy of 20-40%; buffers around these areas should be 3 km (K. Reese, Research Professor, University of Idaho, personal communication).

Featured Species: Turkey

Response of turkeys to recreationists varies. Turkeys in a protected area of Alabama were approached by vehicles with no apparent impact, however, after several years of hunting and an increase in disturbance, birds headed for cover when approached (Wright and Speake 1977). Range abandonment was observed with increased disturbance and harassment.

Management Guidelines

1. Limit disturbance up to 1.5 km around sharp-tailed lek sites and 3 km around sage grouse lek sites.

2. If disturbance is unavoidable, prohibit physical, mechanical or audible disturbances in the breeding complex during the breeding season (March to June) during the daily display period (within 3 hours of sunrise and sunset).

3. In areas managed for turkeys, minimize the number of roads open to public use. Restrict off-trail/off-road use (Wright and Speake 1977).

BIRDS OF PREY

Birds of prey include kites, hawks (including eagles and falcons), osprey and owls. These species are commonly defined as diurnal and nocturnal (owls) raptors, although several of the owls also have diurnal and/or crepuscular foraging habits. Vultures have historically been considered raptors and are discussed in this section. Montana is home to the turkey vulture, 2 eagles, 13 hawks, osprey, and 15 owls for nesting and/or migration and wintering habitats (MBDC 1996). Newton (1979: 290) offered this explanation for raptor distribution "My overall conclusion is that, in the absence of human intervention, almost every aspect of the natural population ecology of a given raptor species can be explained in the terms of food: its dispersion over the countryside, its density in different areas and in different years; the extent of its numerical fluctuations; its breeding seasons and breeding rates; and its seasonal movements and dispersal." All raptors are protected by their inclusion under the 1972 Migratory Bird Treaty Act (16 USC 703, 1918) and by the Lacey Act of 1900 (Millsap 1987). In Montana, raptors are also protected under the Nongame and Endangered Species Conservation Act of 1973.

"Raptors are high-trophic-level predators, and because of their sensitivity to environmental perturbations are aptly called 'indicators' of ecosystem quality. Management to benefit raptors often protects a diversity of habitats and therefore provides benefits to a wide spectrum of other wildlife species" (Hair 1987).

Nationwide, as human populations increase, pressure for subdivision of land may further conflict with raptors. Montana not only has increased demands from residents for outdoor recreation, but these are economic incentives to establish the state as a recreation destination. "The problem created by tourism and recreation is familiar to every naturalist. One solution is to try to restrict such development as much as possible to the places where it will do least harm, and prevent its uncontrolled spread through all wild places" (Newton 1979: 227). Without management for essential habitats, raptor populations may decline. Because raptors are generally long-lived species that exhibit territorial tenacity, long-term monitoring programs are necessary to determine population trends. It is important to manage raptors in as natural and wild condition as possible by protecting prey populations, foraging areas, nesting areas/sites, and roosting areas/sites (Call 1979).

Human activities, including recreation, are known to impact raptors in at least 3 ways: (1) by physically harming or killing eggs, young, or adults; (2) by altering habitats; and (3) by disrupting normal behavior (Postovit and Postovit 1987, Richardson and Miller 1997). Recreational shooting causes direct mortalities and indirect poisoning from carrion containing lead shot. Recreational trapping causes raptor injuries and deaths from accidental take (Redig et al. 1983).

Fyfe and Olendorff (1976) called for "knowledgeable trespass" on a raptor's nesting territory or no trespass at all. During courtship and nest building raptors may be extremely sensitive to disturbance and may desert the nest site. Recreational or research disturbance of a nesting area or nest site may cause any of the following problems: (1) the parent birds may become so disturbed that they desert their eggs or young completely; (2) the incidence of egg breakage or trampling of young by parent birds may be increased, as may the chances of cooling, overheating, loss of humidity, and avian predation of eggs; (3) newly hatched birds may be chilled or overheated and may die in the absence of brooding; (4) older nestlings may leave the nest prematurely, damaging still growing feathers and breaking bones at the end of futile first flights, or may be forced to spend one night or several on the ground where they may be highly vulnerable to predation; (5) mammalian predators may follow human scent trails directly to the eggs and young; (6) the attention of other people may be attracted by the visitor's activities; (7) mishandling a nestling may damage feathers, bones, and claws; and (8) on cliffs, the visitor may inadvertently knock rocks and other debris onto eggs or young birds" (1976:5).

Alteration of habitat includes physical removal of nest and potential nest trees, roost, and potential roost trees and groves, as well as screening vegetation and/or perches from foraging areas. High levels of human activity can reduce or eliminate raptor use of physically unaltered suitable habitat or remnant vegetation left for them. Alteration of habitat may also impact abundance and availability of prey species. Where levels of human disturbance are low and the prey base is protected, addition of artificial replacement perches for foraging may be beneficial.

Recreational disturbance disrupts raptor behavior when it deters foraging or flushes birds from foraging perches and day or night roosts. Flushing distances from pedestrians and vehicles (Fraser et al. 1985, White and Thurow 1985, Holmes et al. 1993) and from boats (McGarigal et al. 1991) have been recorded for some species. The increased energy expenditure of avoidance flights from perches is particularly stressful during periods of prey scarcity and/or severe weather (Stalmaster and Newman 1978, Stalmaster 1987, Buehler et al. 1991, Grubb et al. 1992).

General Management Guidelines

Recreational disturbance can alter normal raptor activity patterns, therefore, managers have two choices: (1) completely deny human access to important raptor habitat, (2) develop a management plan for coexistence with spatial and/or temporal restrictions on recreational disturbance (Knight and Skagen 1988). The development of biologically sound management guidelines for birds of prey requires the following site-specific information: species, sensitivity, essential habitat, season, topography, vegetation, foraging areas, prey base, roosts, sources of recreational disturbance, cumulative human disturbance, and population status. Anderson et al. (1990) warns that short-term responses to disturbance can lead to long-term raptor community changes.

General raptor guidelines (adapted in part from Dubois and Hazelwood [1987] for the Rocky Mountain Front) include:

1. Develop public information and educational programs targeting the recreational users and the relevant species for the focal area.

2. Discourage and/or carefully plan all human-related activities that will occur in key raptor habitats or key use areas, which result in long-term habitat alteration.

3. Identify nest sites (Call 1978) and establish appropriate temporal and spatial buffers for the nesting period. Approximate nest dates for some raptors of the Rocky Mountain Front are listed in Dubois and Hazelwood (1987:37). Buffer zones should exclude all predictable activities, be adjusted for species, pair sensitivity to human disturbance, and other site-specific information. Dubois and Hazelwood (1987) recommended the following spatial buffer zones for particular human disturbances on the Rocky Mountain Front during sensitive nesting phases:
    - off-road vehicle use: 0.4-1.2 km
    - camping and hiking: 0.4-1.2 km
    - rock climbing: 0.8-1.2 km
    - trail clearing: 0.4-0.8 km
    - building/construction: 0.8-4.8 km
    - aircraft flights (low altitude): 0.4-1.6 km

4. Avoid all human disturbance at nesting territories during sensitive nesting phases (Steenhof 1987): (1) just prior to egg laying to just after onset of incubation; (2) hatching to when young become endothermic: 5 days in most raptors to 14 days in bald eagles (Stalmaster 1987) to the last few days before young fledge. Temporal buffers encompassing at least the early fledgling period would prevent potential recreational disturbance-caused premature fledging and/or decreased prey deliveries to dependent fledglings.

5. If necessary to approach a nest for research, approach in a slow, tangential manner, in view of the birds, considering time of day and weather (avoid cold, wind, rain, and heat) (Kurvits 1989).

6. Manage travel corridors so that vehicles, pedestrians, and boats approach perched raptors tangentially and do not stop or remain in the immediate area of the perched birds.

7. Develop site-specific habitat management plans for unique or special habitat features or areas, which tend to concentrate raptors in the nesting, wintering, or migration periods. Include temporal and spatial buffers, predictable routes for any potential human disturbance, and blinds for research and viewing.

8. Promote regulations intended to prevent trapping, poisoning, and shooting of raptors.

9. Reveal raptor nest-site locations only to authorized personnel.

10. Monitor prey availability and prey cycles (Craighead and Craighead 1956, Baker and Brooks 1981).

11. Protect secure roosting areas with temporal and spatial buffers and with restrictions on gunfire and other loud percussive noise that might flush birds from the roost.

12. Establish a long-term population-monitoring strategy.

Diurnal Raptors

Three diurnal raptors have no confirmed records of overwintering in Montana: turkey vulture (*Cathartes aura*), Swainson's hawk (*Buteo swainsoni*), and osprey (*Pandion haliaetus*). The ferruginous hawk (*Buteo regalis*) occasionally is seen in winter but its status of wintering or wandering migrant is still in question. Two winter residents have no documented breeding: rough-legged hawk (*Buteo lagopus*) and gyrfalcon (*Falco rusticolus*). Bald eagles (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*), northern harrier (*Circus cyaneus*), sharp-shinned hawk (*Accipiter striatus*), Cooper's hawk (*Accipiter cooperii*), northern goshawk (*Accipiter gentilis*), red-tailed hawk (*Buteo jamicensis*), American kestrel (*Falco sparverius*), merlin (*Falco columbarius*), prairie falcon (*Falco mexicanus*) and peregrine falcon (*Falco peregrinus*) are present throughout the year. Additional numbers of these species migrate through Montana to and from southern wintering areas (MBDC 1996).

Both on-road and off-road vehicles have the potential to disrupt nesting activity of a number of vulnerable bird species that nest on cliffs. The limited nature of suitable cliff-nesting sites, in turn, limits the flexibility of associated species of finding alternative nesting sites when historical nesting areas are disturbed by motorized activity. Species such as turkey vultures, common ravens (Hooper 1977), golden eagles and prairie falcons (Fyfe and Olendorff 1976) can be disturbed during the nesting season by human intrusion, with a potential loss of productivity due to disruption of courtship activities, over-exposure of eggs or young birds to weather, premature fledging of juveniles, or direct mortality from shooting and harassment. Although establishment of no-disturbance buffer zones around raptor nesting sites has been recommended as protection (Suter and Jones 1981), this management approach also draws attention to these critical sites.

Featured Species: Bald Eagle

The bald eagle was federally listed as endangered in Montana in 1978 (43 CFR 6233), granting it special protection under the Endangered Species Act of 1973 (16 USC 1532, 1982 amend). It is also protected under the Bald Eagle Protection Act of 1940 (16 USC 668). Currently, Montana lists the bald eagle as a "Species of Special Interest or Concern" (Flath 1984). During July 1995 the bald eagle was downlisted from endangered to threatened in Montana. A proposal for delisting was prepared and published in July 1999. Delisting is expected during 2000. Five years of intensive monitoring will follow delisting (MBEWG 1994; R. Hazlewood, Biologist, USFWS, personal communication).

Breeding territories are associated with rivers, lakes, and reservoirs. Large stick nests in old-growth trees and rarely on cliffs are usually located within 1.6 km of the water body and are used for several years. Optimum sites are along shorelines in order to maximize foraging opportunities, however, over time, successive nests on some territories are constructed farther from shore because of increased human activity (Anthony and Isaacs 1989, Harmata and Oakleaf 1992). The size and shape of the breeding territory depends on prey abundance and availability. In Montana, egg laying varies from February into April, incubation spans 31 to 35 days, the nestling period lasts 11 to 14 weeks, and fledglings are dependent on adults for 6 to 10 weeks, with dispersal occurring as late as October (MBEWG 1994).

Many bald eagles nesting in Canada, where prey species are unavailable in winter, migrate to or through Montana for winter foraging areas. While in Montana they exploit ephemeral fish runs such as kokanee salmon and mountain whitefish, ungulate wintering areas and their associated roadkill, ranch carrion, waterfowl and fish where water is ice-free, jackrabbits, and, in the spring, emerging ground squirrels (Harmata 1984, Caton et al. 1989, McClelland et al. 1994). These foraging areas and their associated roosts are critical for eagle survival and breeding fitness for the next nesting season (Newton 1979). The Canadian eagles intermingle with resident eagles at foraging areas. As many as 630 eagles at McDonald Creek, Glacier National Park (McClelland et al. 1994), and 300 eagles at Hauser Reservoir (Restani and Harmata 1993) have been seen on single counts in autumn; 150 have been counted on the Yellowstone River in spring (D. Flath, Biologist, MDFWP, personal communication). Mid-winter counts in January averaged 450 with 600 in high years; it is estimated that twice the count actually winter in the state (MBEWG 1994).

The Montana bald eagle Management Plan (1994: 4) summarizes bald eagle reactions to human activities, "bald eagles are sensitive to a variety of recreational, research, resource and urban development activities." Responses of eagles may vary from ephemeral, temporal, and spatial avoidance of activity to total reproductive failure and abandonment of breeding areas. Less adequately documented is that bald eagles also may tolerate apparently significant disturbances (Harmata and Oakleaf 1992). Relationships of human activity and eagle responses are highly complex, difficult to quantify, and often site-specific. Responses vary depending on type, intensity, duration, timing, predictability, and location of human activity. The way in which these variables interact depends on age, gender, physiological condition, sensitivity, residence, and mated status of affected eagles. Prey base, season, weather, geographic area, topography, and vegetation in the vicinity of activities and eagles (plus other variables probably unperceived by humans) also influence eagle responses. Cumulative effects of many seemingly insignificant or sequential activities may result in disruption of normal behavior (Montopoli and Anderson 1991).

Management Recommendations/Guidelines - Federal listing of the bald eagle as endangered prompted formation of the Montana Bald Eagle Working Group (MBEWG), which authored the 1986 Montana Bald Eagle Management Plan under the Recovery Plan for the Pacific bald eagle (USFWS 1986). The Montana Bald Eagle Management Plan was revised in July 1994 and should be consulted for any management activity affecting bald eagles. The Habitat Management Guide for bald eagles in Northwestern Montana (MBEWG 1991) was an abbreviated form of the plan addressing Montana's population in the Upper Columbia Basin. The southwestern corner of Montana was included in the greater Yellowstone ecosystem. Management decisions in that area should be made under recommendations of the Greater Yellowstone Bald Eagle Management Plan, 1995 Update (GYBEWG 1996).

1. Plan for long-term monitoring of productivity, migrant concentrations and environmental contaminants.

2. Identify areas where 30 eagles or more congregate within 1.5 square kilometers for more than 7 days (MBEWG 1994).

3. Develop nesting habitat management plans for clustered nests; nest-site management zones (concentric buffers of 0.4 km for nesting areas, 0.8 km for primary-use area, and 4.0 km for home ranges) for nests with no site-specific information is available; general breeding area plans with the nest buffer zones adjusted for topography and potential foraging areas; and research-supported, site-specific management plans.

4. Identify and survey suitable nesting habitat (Wright and Escano 1986, Jensen 1988) where there is an adequate prey base (Hansen 1987, Dzus and Gerrard 1993).

5. Manage seasonal foraging areas so they are free of human harassment by establishing buffer zones of 0.4 km around high-use foraging areas with temporal restrictions in areas of high human use (such as fishing, boating, rafting) and buffer zones of 0.2 to 0.4 km (dependent upon vegetative screening) around diurnal perches removed from foraging areas. Remove road-killed ungulates to safe locations for foraging.

6. Make seasonal communal roosts secure by site-specific protection of roosts from human disturbance.

Featured Species: Golden Eagle

Golden eagles are protected under the Bald Eagle Protection Act of 1940, amended in 1962 (P.L. 87-844). Montana's golden eagle population may currently be declining; productivity has been low even though increased survey efforts have resulted in more nests being found. There has been a subtle shift from prominent cliffs to secluded nest trees. The prey base has been poor with spotty distribution of squirrels and low numbers of jackrabbits (A. Harmata, Biologist, Montana State University, personal communication).

Although early researchers such as Ellis (1973) did not perceive nest visits to cause excessive disturbance, anecdotal information (Knight and Skagen 1995) suggests that cumulative impacts on birds of prey from increased recreational activities (e.g., rockclimbing), may result in reduced nesting success or nest abandonment (A. Harmata, Biologist, Montana State University, personal communication).

Management Recommendations/Guidelines -

1. Establish spatial nest buffer with median distance of 800 m (range 200-1600 m) (Richardson and Miller 1997). A geographic information system-assisted viewshed approach combined with a designated buffer zone distance was found to be an effective tool for reducing potential disturbance to golden eagles in northern Colorado (Knight and Gutzwiller 1995).

2. Extend temporal buffers through fledging. Richardson and Miller (1997) cite inclusive dates of February to September. Dates should be site-specific and consider the fledgling period.

3. Discontinue banding of nestlings until cumulative impacts have been studied for long-term behavioral effects on territorial pairs.

4. Restrict motorized recreational vehicles from traveling along ridges above cliffs and from topping high points in suitable golden eagle habitat and nesting areas.

5. Establish a spatial buffer (300 m) to prevent 90% of foraging golden eagles from flushing from perches (ranges: pedestrian = 105-390 m, vehicle = 14-190 m) (Holmes et al. 1993).

Featured Species: Osprey

The osprey is a "Species of Special Concern" in Montana. The population has recovered from low levels in the 1960s caused by DDT contamination. Ospreys return to Montana in March and April, young fledge in July and August, and, by October, ospreys have started their migration to Central and South America for the winter. Ospreys nest near lakes, reservoirs, and rivers, preying on fish and occasional small mammals and are particularly abundant in the western part of the state. Large stick nests are built on tops of trees and on power poles and other man-made structures. Although ospreys often nest in proximity to human activity they are still sensitive to recreational disturbance. In a study at Eagle Lake, California, 33% of egg loss was caused by human disturbance (Garber 1972). Preferred nest locations are along shorelines close to foraging areas. Where large trees are no longer available, they will use the man-made structures or retreat from the shoreline to less disturbed sites. Often ospreys occupy territories when human activity is infrequent prior to the recreation season (Levenson and Koplin 1984). Osprey nests along Yellowstone Lake had significantly lower productivity that appeared to be related to human presence near the nests (Swenson 1975). As with other raptors, ospreys nesting in remote areas are not acclimated to human activities and may be very sensitive to recreational disturbance.

Management Recommendations/Guidelines

1. Establish a median spatial-buffer zone for osprey nest = 1,000 m (range = 400-1500 m) (Richardson and Miller, 1997).

2. Locate campsites at distances of at least 1 km from nests with a temporal buffer zone (Swenson 1975, Alt 1980).

3. Prohibit discharge of firearms within 0.2 km of nest (Kaho 1972).

Feature Species: Turkey Vulture

Turkey vultures are considered common in Montana (Dubois and Becker 1987). Although breeding has been confirmed in only 9 of the 49 latilongs identified by the Montana Bird Distribution Committee (1996), it is suspected in 17 others. Vultures range widely in search of carrion and are considered transient throughout much of the state. They sometimes prey on small mammals. Turkey vultures nest in caves and other cavity type locations but build no nest structure. Nesting begins in April, with young fledging in about 17 weeks. Turkey vultures are known for converging into feeding flocks and using communal roosts. They winter in southern states and Central America. Perhaps because they are not a particularly charismatic species, little specific information is available about the impacts of recreational disturbance on turkey vultures. General raptor guidelines applied with site-specific information should be sufficient to maintain the current status. In recent years, the availability of carrion has been reduced by county regulations requiring burial or removal of dead large animals. This may alter distribution and numbers in the long term. Recreational disturbance near carrion sites could further limit foraging opportunities.

Featured Species: Peregrine Falcon

The peregrine falcon is listed as endangered in Montana, but was recently delisted by the U. S. Fish and Wildlife Service. Peregrines live near open country rivers, marshes, and coasts where cliffs and gorges provide nesting habitat (Clark et al. 1989).

Management Recommendations/Guidelines

1. Establish median spatial buffer for nests at 800 m (range = 800-1600 m) (Richardson and Miller 1997).

2. Restrict rock climbing on cliffs during nesting season (Snow 1972).

3. Establish buffer zone of 8.1 km around foraging sites (Amaral 1982).

Featured Species: Northern Goshawk

Northern goshawk occupy coniferous and mixed forests throughout much of the northern United States, and nesting populations are found locally in the forests of Montana. Goshawks generally remain on their territory throughout the year, but those at higher elevations may shift to lower elevations in the fall (Hayward 1983). Preferred habitat during the breeding season is older forest structures where the goshawk can find large trees in which to nest (Reynolds 1987). The post-fledging area is an area of concentrated use by the goshawk family from the time the young leave the nest until they are no longer dependent on the adults for food. Human disturbances to goshawk nests have been a suspected cause of nest abandonment (Reynolds et al. 1992).

Management Recommendations/Guidelines - The following guidelines are recommended for nest areas and post-fledging areas, March 1 - September 30:

1. Minimize human presence in active nest areas during the nesting season.

2. Maintain low road densities to minimize disturbance.

3. Establish spatial buffer for nest at 400-500 m (Jones 1979).

4. Promote conservative human use of riparian areas where goshawks are foraging and nesting (Jones 1979).

Featured Species: Ferruginous Hawk

The ferruginous hawk was previously classified as a sensitive species by the U.S. Forest Service in Region 1, but was removed from the list in 1999. Western populations of this hawk appear to be stable overall following marked declines in many areas beginning in the late 1940s due to conversion of grasslands and shrublands to croplands (Dobkin 1992). In the northwestern United States, breeding habitat is the management priority as this species migrates south during the winters.

This species breeds primarily in sagebrush and grassland areas where small mammal prey, such as ground squirrels and jackrabbits, are abundant (Dobkin 1992). Preferred nest sites appear to be lone juniper trees, although they will also nest on other structures or on the ground (Woffinden and Murphy 1983, White and Thurow 1985, DeSmet and Conrad 1991). In the Centennial Valley of Montana, willows are also a common nesting structure (Restani 1991). Although reuse of nest sites is common, this may be affected by availability of nest sites in the territory. Therefore, nest surveys should not be limited to known nest sites. Nest site fidelity appears to be the lowest for ground nests (Gilmer and Stewart 1983).

Protection of nesting areas from disturbance is key to maintaining productivity and occupancy of ferruginous hawk breeding sites. The most drastic disturbance occurs with intentional shooting and destruction of young birds within nests (Gilmer and Stewart 1983, Warkentin and James 1988, DeSmet and Conrad 1991). Even when disturbances are not intentional, impacts can be severe. Adults may abandon eggs as well as early hatchlings (White and Thurow 1985, DeSmet and Conrad 1991) and subsequent abandonment of the territory may occurr (White and Thurow 1985). White and Thurow (1985) suggested that a buffer of 250 m between the nest and brief human activity would prevent flushing of birds in most cases (90%) during years when breeding conditions were good; during poorer breeding years, birds may be less tolerant of the stresses related to disturbances.

Unpredictable disturbances appear to have the greatest impact on nesting birds, while more predictable activities, including traffic along established roads, appear more tolerable (White and Thurow 1985, DeSmet and Conrad 1991). This species appears unable to adapt to unpredictable disturbances, and, even when disturbed nests are not abandoned, juvenile mortality risks may increase due to a decline in adult attentiveness (White and Thurow 1985). Juveniles forced to fledge prematurely due to disturbances may be more vulnerable to weather and predators (White and Thurow 1985).

The time frame when disturbances may impact breeding ferruginous hawks will be quite extensive and will include the courtship period through at least the first month after fledging of juveniles. In Montana, this covers an approximate time period from March through August. Disturbance of nesting areas during courtship may force birds to seek greater seclusion in less optimal nesting areas or to abandon territories (Plumpton and Andersen 1998). Use of suboptimal nest structures will likely increase risk of nest destruction due to severe weather, a common cause of nest failure (Gilmer and Stewart 1983, DeSmet and Conrad 1991). Disturbance in key foraging habitats following fledging of juveniles may increase the already high mortality risk of young birds (Schmutz and Fyfe 1987) by disrupting hunting activities or by killing birds in collisions with vehicles.

Habitat quality for breeding ferruginous hawks may vary considerably from year to year based on availability of prey, thus site fidelity can be variable (Smith et al. 1981, Gilmer and Stewart 1983, Woffinden and Murphy 1989). Within breeding territories, nest-site location can also be variable, particularly for ground nests (Gilmer and Stewart 1983). Thus, monitoring of nesting territories will always be required to determine occupancy and location of current nest sites.

Although protection of all occupied nesting territories from disturbances will be important, landscape viability may depend upon identification and management of key source areas where productivity is highest. Relatively small areas with high nest density may serve as focal points of ferruginous hawk production for large regions (Gilmer and Stewart 1983, Woffinden and Murphy 1983).

Management Recommendations/Guidelines

1. Motorized access routes in occupied ferruginous hawk breeding habitat should not run parallel (within 0.3 km) to fence lines and power lines in prime foraging habitat, along riparian areas used for nesting, or fragment prime foraging areas. Monitoring of foraging and nesting activity will be required to identify these areas.

2. Access points for non-motorized and motorized activity in breeding habitat should be kept to a minimum.

3. Management strategies for long-term recreational access should be developed to maximize isolation of, and minimize fragmentation within key breeding and foraging habitat for this species.

Species-Specific Management Recommendations

- Red-tailed hawk: Spatial buffer zone for nest = 800 m (Call 1979). Shifted home range and activity areas during periods of human disturbance (Anderson et al. 1990).

- Rough-legged hawk: Flushing distances while foraging in winter: pedestrian disturbance = 55-900 m; vehicle disturbance = 9-170 m (Holmes et al. 1993). Highly vulnerable to recreational shooting (Zarn 1975, Olson 1999).

- Swainson's hawk: Needs visual screening from human activities at nests.

- Sharp-shinned hawk: Conservative human use of riparian areas used for foraging and nesting on public lands (Jones 1979). Spatial buffer for nest = 400-500 m (Jones 1979).

- Cooper's hawk: Median spatial buffer for nest = 525 m (range = 400-600 m) (Richardson and Miller 1997). Conservative human use of riparian areas used for foraging and nesting on public lands (Jones 1979).

- American kestrel: Median spatial buffer for nest = 50-200 m (Richardson and Miller 1997). Flushing distances while foraging in winter: pedestrian disturbance = 10-100m, vehicle disturbance = 12-115m (Holmes et al. 1993). Food-stressed nesting kestrels may be more sensitive to human disturbance than better-fed birds (Carpenter, 1993).

- Prairie falcon: Median spatial buffer for nest = 650m (range = 50-800m, 4 studies) (Richardson and Miller 1997). Prey habitat must be preserved (Evans 1982).

- Merlin: Flushing distances while foraging in winter: pedestrian disturbance = 17-180m, vehicle = 44-85m (Holmes et al. 1993). Preservation of native prairie is recommended for foraging (Trimble 1975).

- Gyrfalcon: Buffers at winter foraging areas would benefit the occasional gyrfalcon as well as rough-legged and other hawks.

- Northern harrier: Prohibit ATVs and marsh buggies from wet and marshy areas during the nesting season. Protect tall grass communal roost areas.

Nocturnal Raptors

Recreational impacts on owls have been little studied to date. However, it is widely known that raptors are sensitive to many disturbances, whether recreational or, at least during the breeding season. There is abundant evidence that habitat modifications resulting from land-management activities, such as logging, grazing, and development, to name just a few, have a direct impact on raptors. The type of disturbance, time of year the disturbance occurs, and length of time of the disturbance can determine the impact on an individual or breeding pair of raptors. There also may be differences between species when reacting to a particular type of disturbance (Holmes et al. 1993). Certain species can tolerate some types of human presence or disturbance (Hayward and Verner 1994). Some birds avoid human intrusions by nesting higher in the tree canopy, which may lead to problems with thermoregulation and wind damage to the nest (Gutzwiller et al. 1998).

Hiking, off-road vehicle use, camping, and firewood gathering may potentially affect owls through alteration of habitat or because owls will avoid these areas of activity. Non-consumptive recreation (e.g., hiking, camping, boating, snowmobiling, rock climbing, bird watching, off-road vehicle use) has been known to have negative effects on birds (Boyle and Samson 1985, Knight and Gutzwiller 1995). Northern saw-whet owls (*Aegolius acadicus*) found breeding at campgrounds later abandoned their nest area when the campgrounds opened in the spring. Heavily used hiking trails also appeared to reduce owl density (Milling et al. 1997). Direct shooting of burrowing owls (*Speotyto cunicularia*) by prairie dog and gopher hunters may be a significant cause of mortality (Butts 1973, Sheffield 1997). A decrease in prey abundance may also be a threat to burrowing owl productivity.

Several researchers have recommended limiting human activity around nesting owls (Haug and Oliphant 1990, Forsman and Bull 1994). Others have had some success in restoring burrowing owl habitat in areas such as public golf courses and airports. Flammulated owls (*Otus flammeolus*) and boreal owls (*Aegolius funereus*) may be tolerant of some human disturbances (Hayward and Verner 1994). These species have been found nesting in campgrounds and other areas of human activity with no apparent effects.

Owl researchers may also potentially disrupt nesting owls. The use of recorded owl calls for surveying during the owl-breeding season may disrupt breeding activity including courtship. For example, broadcasting a call by a large predatory species, such as the great horned owl (Bubo virginianus) or barred owl (Strix varia), may disrupt calling activity from smaller owls, such as the northern saw-whet, which are potential prey species for the larger owl species (D. Holt, president, Owl Research Institute, Missoula, personal communication).

Owls are attracted to roadsides for several reasons. Hunting perches such as trees, signs, fence posts, and telephone poles and lines attract owls. The interface between the open road and adjacent forest may also attract prey species and afford easier hunting opportunities. In areas heavily dominated by agricultural land, roadside rights-of-way may be the only remaining natural habitat.

Direct mortality to owls from vehicle collisions is well documented. Loos and Kerlinger (1993) considered vehicle collisions a significant mortality factor to northern saw-whet and eastern screech owls (*Otus asio*) in New Jersey. Most of the individuals were young birds dispersing from natal areas during the fall months. Schulz (1986) reported the collection of 150 dead barn owls (*Tyto alba*) per year (on the average) along roadsides in central California. Baudvin (1997) concluded that vehicle collisions in northeastern France were a significant cause of mortality for barn owls and long-eared owls (*Asio otus*). Other research indicates that vehicle collisions are a significant factor in barn owl mortality (Moore and Mangel 1996, Massemin and Zom 1998). Roads and vehicle collisions in fragmented agricultural landscapes may limit burrowing owl populations (Clayton and Schmutz 1997). Others have found that the mere presence of vehicular traffic and high noise levels may result in decreased productivity for burrowing owls when nesting near roads (Plumpton and Lutz 1993). Haug and Oliphant (1990) recommended buffer zones around burrowing owl nest sites that were near primary and secondary roads for protection.

The presence of roads also provides access for humans and the means for other activities to occur including recreational activities, invasion of exotic species, logging, and development (Wasser et al. 1997). The mere presence of roads represents a loss of habitat for owls. This may be inconsequential in open areas with sparse human populations and low road densities, but it may be significant in forested areas where dense logging road systems are present in intensively harvested areas. Roads also may lead to fragmentation effects that may be negative or positive depending upon the species of concern. Roads and the high associated number of road kills may act as population sinks when animals are attracted to the edges to utilize an abundant food source such as insects, small mammals, and birds (Forman 1995).

WOODPECKERS AND OTHER CAVITY-NESTING BIRDS

Several species of woodpeckers (primary cavity nesters) and secondary cavity-nesting birds occur in Montana. Literature reviewed for this paper did not suggest that disturbance from recreationists presented a problem to woodpeckers and cavity nesters as a group. Bent (1939) described the behavior of several species of woodpeckers at their nests as “not shy" when humans were present. Short (1974) described a situation in which black-backed woodpeckers (*Picoides arcticus*) aggressively defended their nest tree while he was repeatedly observing them. While the adverse reaction of woodpeckers to logging or nest observers may be significant, these activities are probably not comparable to random recreation activity. Recreational activity is more likely to be sporadic rather than continuous as in the case of logging, and activity will not likely be focused around nest sites. By design, woodpeckers and other cavity users are relatively more secure from nest predation than any other group of forest birds, therefore it can be assumed that recreational disturbance of woodpeckers is not a major limiting factor.

Recreational logging and harvesting of firewood contribute to loss of snags and/or snag recruitment. Observations of woodcutters suggest that large-diameter snags are preferred for fuelwood. Woodcutters tend to select certain species, depending on the locale and local culture. In western Montana, western larch appears to be the species most often harvested, however Douglas fir and lodgepole pine are also taken. In eastern Montana, lodgepole pine is used extensively, although local woodcutters often travel great distances to harvest large-diameter Douglas fir. In the far eastern portion of the state, cottonwood is the only species available for harvest.

The literature is replete with references to the value of snags to cavity-dependent wildlife (Raphael and White 1976, Milne and Hejl 1989, Bull and Holthausen 1993, Hutto 1995*b*, Hitchcox 1996). Woodpeckers select for certain species, height, and diameter of snags. These studies suggested that firewood cutting was in direct conflict with woodpecker nest success because woodcutters harvested the material most valuable to woodpeckers for nesting (i.e., large, standing snags with a preference for larch, Douglas fir, and cottonwood). As a compounding factor, the extraordinary specialization exhibited by woodpeckers allowed them little flexibility in the sizes, characteristics, and species of snags in which they successfully nested. For instance, most of the nests McClelland (1994) studied were in large-diameter larch, exactly the material that is preferred by woodcutters in western Montana. Lewis' woodpeckers (*Melanerpes lewis*) nested in large diameter cottonwood, exactly the material targeted by woodcutters statewide, particularly on the east side of the state. Douglas fir, another species preferred by woodpeckers, is also highly prized by woodcutters. Two tree species (ponderosa pine and birch) are highly preferred by woodpeckers, yet are not of interest to woodcutters (although there is some evidence that demand for birch may be increasing).

Montana's national forests have few limits on woodcutting compared to other parts of the country. Eastern forests typically limit woodcutting to (live or dead) down material within designated areas. The Mount Hood National Forest in Oregon is generally open to woodcutting, but firewood removal is limited to material that is both dead and down. Not only is firewood removal generally unrestricted in Montana, but observations suggest that the felling of large, standing snags is a cultural aspect of the recreational activity, (i.e., woodcutters will select for large, standing snags rather than smaller down material that would otherwise be safer and easier to harvest). Not only are large-diameter snags selected disproportionately, but the species selected by woodcutters tend to be those preferred by cavity-dependent species (larch and Douglas fir). This places large, high-value snags at extreme risk anywhere woodcutters can gain access to the national forests.

Education is often raised as a possible tool to make woodcutters more sensitive to cavity-nester needs. One of our best examples of a "failed" educational program in Montana was called the "Animal Inn Program." This program, which originated on the Deschutes National Forest in Oregon, was ultimately adopted nationwide. Targeting third graders, it was designed to educate woodcutters (or their children, in this case) on the value of snags, which, in turn, would allow them to make better choices about firewood selection. Although the Animal Inn Program was conducted in Missoula schools during a 3-year period, no change in snag attrition attributable to woodcutters was noted. A logical conclusion of this experience is that education probably has a role in snag protection, but only in concert with on-the-ground restrictions.

The Lolo Forest Plan (USDA 1986) suggested that snag loss to woodcutters was not a problem because woodcutters were typically limited to within 65 m of an open road. That assumption has been proven wrong on several occasions. A local forester (S. Arno, Research Forester, USFS, personal communicaiton) has been successfully logging small woodlots with the use of a 4-wheeled all-terrain vehicle (ATV) for several years in the Missoula area. While he was removing live sawlogs rather than snags, he suggested that snags could be removed from long distances from open roads with relatively cheap, simple technology.

On another landscape that had been logged with a network of closely spaced jammer roads in the 1960s, a group of woodcutters working together systematically skidded out all snags from the area using snowmobiles (V. Applegate, Silviculturist, USFS, personal communication). In this case, after the snags were felled, they were rolled with peaveys onto a sled that was attached to the snowmobile. The sleds, which were the discarded hoods of wrecked automobiles, prevented the snag from digging into the snow while being skidded and made over-the-snow skidding possible.

Another further example of low-tech, long-distance snag yarding is woodcutters who use a "snatch block" attached to a tree on the uphill side of a road. A 1/4" cable is then attached to a snag on the downhill side of the road, the cable is threaded through the block, and a pickup is used to drag the snag uphill. Woodcutters routinely harvest snags up to 200 m from the road in this manner.

Management Recommendations

1. Evaluate snag abundance and risk of loss to recreational woodcutting. Factors to consider include open road density, accessibility of the landscape to ORVs (% slope and vegetative density), local firewood demand, and proximity to communities.

2. Consider any of the following actions to reduce further snag attrition:
   - manage travel corridors to reduce open-road density, to designate routes, and to restrict vehicles to established open roads

   - limit woodcutting to downed material only or to certain species (such as lodgepole pine, spruce, subalpine fir, or other locally available species) that tend to have low values for cavity-dependent species

   - add snag/woodcutting topics to environmental education programs

Management Guidelines

Frissell (1994) presented 5 general guidelines to reduce negative impacts of firewood-cutting:

1. Avoid cutting snags that already show evidence of bird use.

2. Leave all snags larger than 20 inches dbh.

3. Leave snags with broken tops.

4. Avoid cutting trees that show evidence of heart rot.

5. Avoid cutting western larch, ponderosa pine, and black cottonwood.

SONGBIRDS

There are approximately 111 species of songbirds in Montana (MBDC 1996). Birds may respond to human activity by altering their behavior, spatial distribution, and use of habitats (Knight and Cole 1995). Management of songbird habitat where recreation and travel activities occur is essential to prevent reductions in songbird carrying capacity and diversity. Travel corridors created for motorized travel and recreation may fragment songbird habitat, and human activity within songbird habitat may disrupt breeding activity and displace birds.

Forested and Forested-Riparian Habitats

Roads have contributed to forest fragmentation by dissecting large patches into smaller pieces and by converting forest interior habitat into edge habitat (Askins et al. 1987, Small and Hunter 1988, Schonewald-Cox and Buechner 1992, Askins 1994, Reed et al. 1996). Small and Hunter (1988) classified roads as an edge if they could be identified from aerial photographs or USGS topographic maps. Some researchers have considered a corridor at least 10 m in width as having a fragmenting effect (Lynch and Whigham 1984). Rich et al. (1994) recently attempted to quantify the corridor width that creates fragmentation by comparing songbird response to road and powerline corridors 8, 16 and 23 m wide. Corridor widths as narrow as 8 m produced forest fragmentation effects, in part, by attracting cowbirds and nest predators to corridors and adjacent forest interiors. Similar fragmentation effects may also occur with nature trails that are only 2-3 m wide. Hickman (1990) found that nest predators and brown-headed cowbirds (*Molothrus ater*) were attracted into trail-corridor habitat in Illinois.

Habitat fragmentation from corridors can reduce songbird carrying capacity for at least 2 reasons. If roads create significant disruptions of continuous forest habitat, the space required by forest interior species will be reduced. Road corridors 16 m in width appear to have this affect. Rich et al. (1994) found that densities of forest interior species in New Jersey were significantly reduced adjacent to 16 m-road corridors as compared to adjacent interior forest habitat. Similar effects may occur in the Northern Rockies. Hutto (1995*a*) noted that 2 interior species, the brown creeper (*Certhia americana*) and golden-crowned kinglets (*Regulus satrapa*), were twice as likely to occur on points more than 100 m from, rather than adjacent to, a road.

If roads fragment habitat, a number of other Northern Rockies species may also be affected. Hutto (1996) reported that some forest songbirds may not occur as commonly in small as in larger forest patches, including the Townsend's warbler (*Dendroica townsendii*), varied thrush (*Ixoreus naevius*), golden-crowned kinglet, chestnut-backed chickadee (*Parus rufescens*), winter wren (*Troglodytes troglodytes*), red-breasted nuthatch (*Sitta canadensis*), and Swainson's thrush (*Catharus ustulatus*). In Wyoming, Keller and Anderson (1992) found that the brown creeper, hermit thrush (*Catharus guttatus*) and red-breasted nuthatch were associated with larger forest patches.

Fragmentation of limited, high-value habitats may cause some of the most severe impacts to songbirds. Many songbird species are largely or primarily restricted to riparian habitats (Hutto 1995*a*). Fragmentation of riparian habitats with corridors (e.g., trails, roads) will create greater impacts to songbirds on a landscape perspective than fragmentation of adjacent forests.

Fragmentation of habitats may not only reduce patch size for interior species, but may separate important associations between two adjacent habitats. Riparian habitat in conjunction with upslope habitat may be more effective in meeting habitat needs of the entire songbird community in western coniferous forests. McGarigal and McComb (1992) found that while riparian forests in Oregon supported many songbird species, upslope areas were more important in contributing to the avifauna of mature, unmanaged forest stands.

When riparian areas remain only as remnant forests adjacent to cutover areas, fragmentation may be most serious. Minimum corridor widths from 75-175 m have been recommended to include at least 90% of the songbird species, including forest interior species, such as the veery (*Catharus fuscescens*) and pileated woodpecker (*Dryocopus pileatus*) (Spackman and Hughes 1995, Dickson et al. 1995). In studies of fragmented riparian corridors, Vander Haegen and DeGraaf (1996) recommended maintaining a minimum riparian corridor width of 100 m.

The breakup of continuous forest habitat with roads may increase predation rates on songbirds by increasing the ratio of edge to interior habitats. This has been observed in heavily forested areas of Connecticut and Maine (Askins et al. 1987, Small and Hunter 1988). Small fragments may be easier for predators to penetrate, while the adjacent roads will provide predators a travel corridor into forested habitat from nearby areas (Small and Hunter 1988, Askins 1994). Predation rates on eggs were also found to be significantly higher along 100 m of minor roads through otherwise continuous forests in Belize (Burkey 1993). Increases of both cowbirds and nest predators have been observed along unpaved and paved roads in New Jersey (Rich et al. 1994). Increases of cowbirds and nest predators have even been noted along 2-3 m-wide nature trails in Illinois (Hickman 1990), while in Colorado, predation of songbirds was greater closer to forested hiking trails (Miller et al. 1998).

The phenomenon of reduced songbird productivity along edges was recently reviewed by Paton (1994). Nest success varied near edges, with both depredation rates and parasitism rates increasing near edges; in addition, there was a positive relationship between nest success and patch size. The most conclusive studies suggest that edge effects usually occur within 50 m of an edge. Paton (1994) concluded that strong evidence exists that avian nest success declines near edges, and his review corresponds with management recommendations provided by Askins (1994) that if diversity of neotropical migratory songbirds is a management goal, large blocks of continuous forest should not be segmented with roads.

The creation of edge habitat may have the greatest impacts in riparian areas due to the large number of riparian and/or deciduous forest songbirds that are common to frequent hosts for cowbirds. These include the veery (*Catharus fuscescens*), willow flycatcher (*Empidonax traillii*), red-eyed vireo (*Vireo olivaceus*), warbling vireo (*Vireo gilvus*), yellow warbler (*Dendroica petechia*), ovenbird (*Seiurus aurocapillus*), common yellowthroat (*Geothlypis trichas*), yellow-breasted chat (*Icteria virens*), rose-breasted grosbeak (*Pheuticus ludovicianus*), song sparrow (*Melospiza melodia*), Brewer's blackbird (*Euphagus cyanocephalus*), American redstart (*Setophaga ruticilla*), and American goldfinch (*Carduelis tristis*) (Ehrlich et al. 1988). More common cowbird hosts in coniferous forest habitat are more limited, and include vireos (*Vireo* s pp.), black-and-white warbler (*Mniotilta varia*), yellow-rumped warbler (*Dendroica coronata*), and chipping sparrow (*Spizella passerina*) (Ehrlich et al. 1988).

In addition to fragmentation effects, roads and trails in forests likely disrupt songbirds breeding activities and/or displace birds from the zone of disturbance. Even non-motorized activity has documented disturbance impacts to songbirds. Miller et al. (1998) studied bird species density in forest habitat in Colorado and found that generalist species were more abundant near hiking trails, whereas specialist species were less common. The zone of influence averaged about 75 m, but extended to more than 100 m some sensitive species. Similar disturbance impacts were noted for 8 of 13 songbird species along wooded trails in the Netherlands (van der Zande et al. 1984). Because of the noted sensitivity of even common songbirds to disturbance, van der Zande et al. (1984) recommended that recreational disturbance impacts be concentrated into already heavily used areas rather than dispersed.

Motorized activity along roads and trails may have an even greater disturbance and/or displacement effect on birds. One indication of reduced habitat quality along roads is an increased proportion of yearling males during the breeding season. Reijnen and Foppen (1994) found that in wooded habitat adjacent to roads in the Netherlands, the density of territorial male willow warblers was lower because of a low presence of older males. In the road zone (200 m next to the road), the proportion of successful yearling males was only half that of other zones, and overall productivity in this road zone was reduced. Reijnen and Foppen (1994) suggested that, due to source/sink dynamics and emigration, the highway reduced the population size of the entire 400-acre study area, of which 20% belonged to the road zone. For all species present, Reijnen and Foppen (1994) also found that 60% showed evidence of reduced density adjacent to roads. In another study along highways in Maine, Ferris (1979) detected no reductions in overall songbird density, but he noted that 3 interior species were displaced from the highway.

Although few data are available on the direct disturbance impacts of off-road vehicles on songbirds, such impacts will likely be greater than those created by non-motorized activities. Gutzwiller et al. (1997) intentionally disturbed breeding songbirds with scheduled hikes through their territories in a Wyoming forest. The authors were able to detect curtailments of singing activity in some species; this may have reduced breeding activity and the quality of those sites for producing young. Gutzwiller et al. (1998) found tolerance was lower for more conspicuous species, birds that were active nearer to the ground and birds in areas with few conspecifics. Riffell et al. (1996) also studied non-motorized human intrusion into songbird habitat in Colorado coniferous forests. Declines in richness and abundance observed during some years for core species indicates that intrusions have the potential to generate important problems for some or all of these species during the breeding season.

In an analysis of off-road vehicle use on desert avifauna, Luckenbach (1979) noted that in addition to habitat alteration, harassment and noise forced a parent bird to leave an active nest for long periods, thereby exposing young to thermal and water stress. Because young birds are poor thermal regulators, mortality due to abandonment would be expected to be high.

The combined on-site effects of roads and trails due to habitat fragmentation and disturbance activities likely produce notable changes in bird species composition. The implications of these changes may be highly significant when the total mileage of fragmentation/disturbance routes on a local landscape are tallied. These cumulative impacts may be further exacerbated when campgrounds are created within riparian areas to support these recreational routes. When open, campgrounds can reduce both the density and diversity of songbirds (Aitchison 1977). Species that may be most severely impacted by these riparian campgrounds may, in turn, be those that can least tolerate impacts, such as the veery, a species that is experiencing significant population declines throughout the North American continent. In Idaho cottonwood forests, Saab (1996) found that the veery required larger patches of cottonwood forest in areas disturbed by campgrounds. Loss of shrub understories in and around campgrounds reduced key habitat for many riparian species as well (Luckenbach 1979). Locations of campgrounds in riparian areas also impacted nesting of the belted kingfisher, especially when displaced from limited bank-nesting sites or key feeding areas in riffles (Davis 1982).

Grassland/Shrub and Savannah Species

Grassland-shrubland and savannah songbirds may be vulnerable to road and trail activities in manners similar to forest birds. Roads and trails create edge habitat for predators. Miller et al. (1998) found lower nest survival for grassland birds adjacent to rather than removed from hiking trails in Colorado. Johnson and Temple (1990) found that rates of nest predation and brood parasitism for 5 bird species nesting in fragments of tallgrass prairies in Minnesota were affected by the size of the prairie fragment containing the nest; rates of predation were lower for nests on large fragments. Roads and trails have reduced patch size of remaining habitat for area-sensitive species. In Idaho, Knick and Rotenberry (1995) found that fragmentation of shrubsteppe communities significantly influenced the presence of shrub-obligate species, such as the sage sparrow (*Amphispiza belli*), Brewer's sparrow (*Spizella breweri*), and sage thrasher (*Oreoscoptes montanus*).

Although fences are rarely constructed for recreational management, it should be recognized that this activity has the potential to increase cowbird parasitism on songbirds in grassland, shrubland, and savannah habitats. Fencelines have provided perches from which cowbirds can search for host nests (Johnson and Temple 1990). Grassland and savannah species that are most vulnerable to cowbird parasitism include the vesper sparrow (*Pooecetes gramineus*), lark sparrow (*Chondestes grammacus*), clay-colored sparrow (*Spizella pallida*), spotted towhee (*Pipilo maculatus*), and chipping sparrow (Ehrlich et al. 1988).

The disturbance impacts of recreational activities along roads may even be greater in grassland/shrub habitats as opposed to forested habitats, because of the greater impacts of noise. Miller et al. (1998) found that grassland birds were more likely to nest away from rather than near hiking trails in Colorado, with a zone of influence approximating 75 m. Both Van der Zande et al. (1980) and Reijnen et al. (1996) found depressed densities of grassland birds adjacent to roadways in the Netherlands, with disturbance impacts increasing with traffic volume and noise levels. On busy roads (5,000 cars per day), the disturbance distance for some species extended up to 1,700 m; this distance increased to 3,530 m on major highways (50,000 cars per day).

Management Recommendations/Guidelines

1. Motorized activity should be limited to designated routes in forested, grassland, and shrubland habitats from early spring through fall (April-May through September) to avoid disruption of songbird courtship, breeding, nesting, and post-fledging activity.

2. The total-access-corridor density on a local landscape, whether forested, grassland, or shrubland, should be limited to control disturbance and fragmentation impacts on songbirds; corridors with increasing width and motorized use should be assigned progressively higher disturbance values and be more restricted in density.

3. No new roads, trails, or campgrounds should be established in riparian areas (600 m adjacent to the stream border) or cottonwood forests. The greater the disturbance or fragmentation value of a corridor, the higher it should be placed upslope from the riparian area.

4. Short- and long-term objectives should emphasize concentration rather than dispersal of the fragmentation/disturbance impacts of recreation and motorized access within songbird habitat. Corridor activities should be combined where feasible, and new or relocated corridors should be located in areas already fragmented, including natural edges such as breaks between forests and grasslands. Caution should be used when constructing fences along existing roads since cowbirds may benefit.

5. Long-term objectives should be established to identify and avoid disturbance or fragmentation of large blocks of forest/grassland/sagebrush habitats with recreational and travel corridors. Wildlife habitat should be zoned for maintenance of large unfragmented, undisturbed blocks of forest, grassland, and sagebrush habitat.

6. High-value wildlife areas that are currently disturbed and/or fragmented by travel/recreation corridors, particularly riparian and cliff habitats; large blocks of sagebrush; and low-elevation, old-growth forests, should be targeted for restoration.

Cliff Habitats

Cliffs are unique features in Montana's landscape because they create abrupt edges and provide habitats for a wide diversity of birds. Cliff habitats are generally inaccessible to humans and livestock and may be the least-disturbed features of a landscape (Camp and Knight 1998). During the last few decades, the sport of rock climbing has attracted an ever-increasing number of recreationists and has contributed to changes in cliff bird communities (Pyke 1997). Knight and Skagen (1988) suggested that rock climbing reduced nesting success of birds. Camp and Knight (1998) suggested that rock-climbing activities affected the diversity of species as well as species behavior. The number of observations for species, such as canyon wrens (*Catherpes mexicanus*), rock wrens (*Salpinctes obsoletus*), tree swallows (*Tachycineta bicolor*), and Lazuli buntings (*Passerina amoena*), differed depending on the frequency that cliffs were climbed. Cliff habitats may deserve special management attention, therefore, management recommendations from Camp and Knight (1988) follow.

Management Recommendations/Guidelines

1. Monitor expanded use of cliffs by climbers.

2. Implement monitoring programs to evaluate spatial and temporal fluctuations of bird species and changes in numbers of invasive species.

CONCLUSIONS

Wildlife and recreationists can coexist at a variety of spatial, temporal, and behavioral levels if responsible management and cooperation among users of public lands is maintained (Knight and Temple 1995). In this chapter, we presented *management guidelines*, based on results of specific studies, and *management recommendations*, based on our synthesis of the literature and what is known about species behavior. Managers should consider these to be minimum-acceptable considerations for protecting bird species in Montana. However, we acknowledge that managers are often faced with limited funding and are forced to prioritize management needs of species with the result that all guidelines cannot be met. When possible, we recommend that prioritizations be based on data, and we urge managers to use this guide as a tool to help them in this process. We also recommend Carter et al. (1998) to assist with development of conservation priorities given budget limitations and limited data.

INFORMATION NEEDS

The literature we reviewed for this paper was skewed toward specific species and behaviors. For instance, literature on disturbance to nesting birds is quite extensive and demonstrates a relationship between nest success and disturbance. Recreational impacts on waterfowl, raptors, colony nesters, and East Coast shorebirds are well-documented. Gaps in the literature exist for specific species as well as species groups. Gaps also occur for recreational impacts that occur outside of the breeding season.

LITERATURE CITED

Aitchison, S. W. 1977. Some effects of a campground on breeding birds in Arizona. Pages 175-182 *in* Proceedings of a symposium, importance, preservation and management of riparian habitat. U.S. Forest Service General Technical Report RM-43.

Alt, K. L. 1980. Ecology of breeding bald eagle and osprey in the Grant Teton-Yellowstone National Parks complex. Thesis, Montana State University, Bozeman, 94pp.

Amaral, M. 1982. Recommended restrictions for protection of peregrine falcons in Alaska. Pages 217-233 *in* proceedings of a symposium and workshop, raptor management and biology in Alaska and western Canada, Feb 17-20, 1981, Anchorage, Alaska. USFWS, Anchorage.

Anderson, D. E., O. J. Rongstad, and W. R. Mytton. 1990. Home range changes in raptors exposed to increased human activity levels in southeastern Colorado. Wildlife Bulletin 18:134-142.

Anderson, J. M. 1978. Protection and management of wading birds. Pages 99-103 *in* A. Sprunt, J. C. Ogden and S. Winckler, eds. Wading Birds. National Audubon Society Research Report 7.

Anthony, R. G., and F. B. Isaacs. 1989. Characteristics of bald eagle nest sites in Oregon. Journal of Wildlife Management 53:148-159.

Ashley, J. 1994. 1992-3 Harlequin duck monitoring and inventory in Glacier National Park, Montana. Unpublished report. Division Resource Management Glacier National Park, Montana. 57pp.

Askins, R. A. 1994. Open corridors in a heavily forested landscape: impact on shrubland and forest-interior birds. Wildlife Society Bulletin 22:339-347.

Askins, R. A., M. J. Philbrick, and D. S. Sugeno. 1987. Relationship between the regional abundance of forest and the composition of forest bird communities. Biological Conservation 39:129-152.

Baker, J. A., and R. J. Brooks. 1981. Distribution patterns of raptors in relation to density of meadow voles. Condor. 83: 42-47.

Baudvin, H. 1997. Barn owl *(Tyto alba)* and long-eared owl *(Asio otus)* mortality along motorways in Bourgogne-Champagne: report and suggestions. Pages 58-61 *in* Symposium Proceedings: Biology and Conservation of Owls of the Northern Hemisphere. U.S. Forest Service General Technical Report NC-190.

Baydack, R. K., and D. A. Hein. 1987. Tolerance of sharp-tailed grouse to lek disturbance. Wildlife Society Bulletin 15:535-539.

Bent, A. C. 1939. Life histories of North American woodpeckers. U.S. Natl. Mus. Bull. 174. Smithsonian Inst. Washington D.C. 334pp.

Boyle, S. A., and F. B. Samson. 1985. Effects of nonconsumptive recreation on wildlife: a review. Wildlife Society Bulletin 13:110-116.

Braun, C. E., K. W. Harmon, J. A. Jackson, and C. D. Littlefield. 1978. Management of national wildlife refuges in the United States: its impacts on birds. Wilson Bulletin 90(2):309-321.

Buckley, P. A., and F. G. Buckley. 1978. Guidelines for the protection and management of colonially nesting waterbirds. National Park Service, North Atlantic Regional Office, Boston.

Buehler, D. A., T. J. Mersmann, J. D. Fraser, and J. K. D. Seegar. 1991. Effects of human activity on bald eagle distribution on northern Chesapeake Bay. Journal of Wildlife Management 55(2):282-290.

Bull, E. L., and R. S. Holthausen. 1993. Habitat use and management of pileated woodpeckers in northeastern Oregon. Journal of Wildlife Management 57: 335-345.

Bull, E. L., and J. E. Jackson. 1995. Pileated Woodpecker (*Dryocopus pileatus*). *In* A. Poole and F. Gill, eds. The Birds of North America, No. 148. The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union,Washington D. C.

Burger, J. 1991. Foraging behavior and the effect of human disturbance on the piping plover. Journal of Coastal Research 7(1):39-52.

Burger, J. 1997. Effects of motorboats and personal watercraft on flight behavior over a colony of common terns. Condor 100:528-534.

Burger, J., M. Gochfeld, and L. J. Niles. 1995. Ecotourism and birds in coastal New Jersey: contrasting responses of birds, tourists and managers. Environmental Conservation (22):56-65.

Burkey, T. V. 1993. Edge effects in seed and egg predation at two neotropical rainforest sites. Biological Conservation 66:139-143.

Butts, K. O. 1973. Life history and habitat requirements of burrowing owls in western Oklahoma. Thesis, Oklahoma State University, Stillwater, OK. 188pp.

Call, M. 1978. Nesting habitats and surveying techniques for common western raptors. Bureau of Land Management, Technical Note 316, Denver. 115pp.

Call, M. 1979. Habitat management guides for birds of prey. Bureau of Land Management, Technical Note 338, Denver. 70pp.

Camp, R. J., and R. L. Knight. 1998. Rock climbing and cliff bird communities at Joshua Tree National Park, California. Wildlife Society Bulletin 26(4):892-898.

Carpenter, G. P. 1993. Effects on food availability and disturbance on nesting American kestrels in southwest Idaho. Snake River Birds of Prey National Conservation Area Research and Monitoring, Annual Report.

Carter, M. F., W. C. Hunter, and D. N. Pashley. 1998. Setting landbird conservation priorities for states, provinces, and physiographic areas of North America. Colorado Bird Observatory. 17pp.

Caton, E. M., M. Donofrio, and B. R. McClelland. 1989. Spring migration of a juvenile bald eagle from Glacier National Park: habitat use and management recommendations for the Missouri River. National Park Service, Research Division, Glacier National Park, West Glacier, Montana. 13pp.

Clark T. W., A. H. Harvey, R. D. Dorn, D. L. Genter, and C. Groves, eds. 1989. 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. 153pp.

Clarkson, P. 1992. A preliminary investigation into the status and distribution of harlequin ducks in Jasper National Park. Unpublished Technical Report. Natural Resource Conservation, Jasper National Park, Alberta. 63pp.

Clayton, K. M., and J. K. Schmutz. 1997. burrowing owl *(Speotyto cunicularia)* survival in prairie Canada. Pages 107-110 *in* Symposium proceedings: biology and conservation of owls of the Northern Hemisphere. U.S. Forest Service General Technical Report NC-190.

Craighead, J. J., and F. C. Craighead. 1956. Hawks, owls and wildlife. Stackpole Co., Harrisburg, Pennsylvania.

Davis, W. J. 1982. Territory size in *Megaceryle alcyon* along a stream habitat. Auk 99:353-362.

Deblinger, R. D., J. J. Vaske, M. P. Donelly, and R. Hopping. 1991. Pages 61-65 *in* Shorebird and boater impact management. Proceedings of the 1991 northeastern recreational research symposium, April 7-9, 1991, Sarasota Springs, New York. U.S. Northeast Forest Experiment Station, Radnor, Pennsylvania.

DeSmet, K. D., and M. P. Conrad. 1991. Status, habitat requirements, and adaptions of ferruginous hawks in Manitoba. Pages 219-221 *in* Proceedings of the second endangered species and prairie conservation workshop. Provincial Museum of Alberta, Natural History Occasional Paper No. 15.

Dickson, J. G., J. H. Williamson, R. N. Conner, and B. Ortego. 1995. Streamside zones and breeding birds in eastern Texas. Wildlife Society Bulletin 23:750-755.

Dobkin, D. S. 1992. Neotropical migrant landbirds in the Northern Rockies and Great Plains: a handbook for conservation and management. U.S. Forest Service, Northern Region, Publication No. R1-93-34, Missoula, Montana.

Dubois, K., and D. Becker. 1987. Identification of Montana's birds of prey. Supplement to Montana Outdoors, Nov/Dec 1987. Montana Department of Fish, Wildlife and Parks, Helena.

Dubois, K., and R. Hazelwood. 1987. Raptors. Pages 29-37 *in* Interagency Rocky Mountain Front Wildlife Monitoring/Evaluation Program. Bureau of Land Management.

Dzus, E. H., and J. M. Gerrard. 1993. Factors influencing bald eagle densities in northcentral Saskatchewan. Journal of Wildlife Management 57:771-778.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye. 1988. The birder's handbook: a field guide to the natural history of North American birds. Simon and Schuster Inc., New York, London, Toronto, Sydney, Tokyo, Singapore.

Ellis, D. H. 1973. Development of behavior in the golden eagle. Wildlife Monographs 70:1- 94.

Erwin, R. M. 1989. Responses to human intruders by birds nesting in colonies: experimental results and management guidelines. Colonial Waterbirds 12(1):104-108.

Evans, D. L. 1982. Status reports on twelve raptors. USFWS Special Scientific Report. Wildlife 238. 68pp.

Ferris, C. R. 1979. Effects of Interstate 95 on breeding birds in northern Maine. Journal of Wildlife Management 43:421-427.

Flath, D. L. 1984. Vertebrate species of special interest or concern: mammals, birds, reptiles, amphibians, fishes. Montana Department of Fish, Wildlife and Parks, Wildlife Division, Helena. 76pp.

Flemming, S. P., R. D. Chiasson, P. C. Smith, P. J. Austin-Smith and R. P. Bancroft. 1988. Piping plover status in Nova Scotia related to its reproductive and behavioral responses to human disturbance. Journal of Field Ornithology 59(4):321-330.

Forman, R. T. 1995. Land mosaics: the ecology of landscapes and regions. Cambridge University Press. Cambridge, England. 632pp.

Forsman, E., and E. L. Bull. 1994. Great horned, great gray, spotted and barred owls. Pages 118-123 *in* Proceedings of the Western Raptor Management Symposium and Workshop, Washington, D.C. National Wildlife Federation.

Fraser, J. D. 1985. The impact of human activities on bald eagle populations-a review. Pages 8-84 *in* J. M. Gerrard and T. M. Ingram eds. The bald eagle in Canada. Proceedings of bald eagle Days 1983. White Horse Plains Publ., Headingly, Manitoba.

Fraser, J. D., L. D. Frenzel, and J. E. Mathisen. 1985. The impact of human activities on breeding bald eagles in northcentral Minnesota. Journal of Wildlife Management 49:585-592.

Frissell, S. 1994. The impact of firewood cutting on hole-nesting birds. Western Wildlands 9(4):28-30

Fyfe, R. W., and R. R. Olendorff. 1976. Minimizing the dangers of nesting studies to raptors and other sensitive species. Canadian Wildlife Service, Information Canada, Catalogue No. CW69-1/23. Ottowa.

Gaines, E. P., and M. R. Ryan. 1988. Piping plover habitat use and reproductive success in North Dakota. Journal of Wildlife Management 52(2):266-273.

Garber, D. P. 1972. osprey nesting ecology in Lassen and Plumas counties, California. Thesis, California State University, Humbolt. 59pp.

Gilmer, D. S., and R. E. Stewart. 1983. ferruginous hawk populations and habitat use in North Dakota. Journal of Wildlife Management. 47(1):146-157.

Graul, W. D. 1975. Breeding biology of the mountain plover. Wilson Bulletin. 87(1):6-31.

Greater Yellowstone Bald Eagle Working Group (GYBEWG). 1996. Greater Yellowstone bald eagle management plan: 1995 update. Wyoming Game and Fish Department, Lander. 47pp.

Grier, J. W. 1969. Bald eagle behavior and productivity responses to climbing nests. Journal of Wildlife Management 33(4):961-966.

Grubb, T. G., W. W. Bowerman, J. P. Geisy, and G. A. Dawson. 1992. Responses of breeding bald eagles to human activities in north central Michigan. Canadian Field Naturalist 106:443-453.

Gutzwiller, K. J., E. A. Korese, S. H. Anderson and C. A. Wilkins. 1997. Does human intrusion alter the seasonal timing of avian song during breeding periods? Auk 114:55-56.

Gutzwiller, K. J., H. A. Marcum, H. B. Harvey, H. D. Roth, and S. H. Anderson. 1998. Bird tolerance to human intrusion in Wyoming montane forests. Condor. 100:519-527.

Hair, J. D. 1987. Preface. Page v *in* B. A. Giron Pendleton, B.A. Millsap, K. W. Cline, and D. M. Bird, eds. Raptor management techniques manual. National Wildlife Federation, Scientific Technical Service No. 10. Washington, D. C.

Hansen, A. J. 1987. Regulation of bald eagle reproductive rates in southeast Alaska. Ecology 68(5):1387-1392.

Harmata, A. R. 1984. Bald eagles of the San Luis Valley, Colorado: their winter ecology and spring migration. Dissertation, Montana State University, Bozeman. 222pp.

Harmata, A. R., and B. Oakleaf. 1992. Bald eagles in the Greater Yellowstone Ecosystem: an ecological study with emphasis on the Snake River, Wyoming. Wyoming Game and Fish Department Report, Cheyenne, Wyoming.

Haug, E. A., and L. W. Oliphant. 1990. Movements, activity patterns, and habitat use of burrowing owls in Saskatchewan. Journal of Wildlife Management 54:27-35.

Hayward, G. D. 1983. Nest habitat selection in the northern region. U. S. Forest Service. Wildlife and Fish Habitat Relationships Program. Missoula, Montana.

Hayward, G. D, and J. Verner. 1994. Flammulated, boreal, and great gray owls in the United States: a technical conservation assessment. U.S. Forest Service, General Technical Report RM-253.

Heimberger, M., D. Euler, and J. Barr. 1983. The impact of cottage development on common loon reproductive success in Central Ontario. Wilson Bulletin 95(3):431-439.

Henson, P., and T. A. Grant. 1991. The effects of human disturbance on trumpeter swan breeding behavior. Wildlife Society Bulletin 19(3):248-257.

Hickman, S. 1990. Evidence of edge species attraction to nature trails within deciduous forest. Natural Areas Journal 10:3-5.

Hitchcox, S. M. 1996. Abundance and nesting success of cavity nesting birds in unlogged and salvage logged burned forest in northwestern Montana. Thesis. Univ. of Montana, Missoula, 89pp.

Holmes, T. L., R. L. Knight, L. Stegall, and G. R. Craig. 1993. Responses of wintering grassland raptors to human disturbance. Wildlife Society Bulletin 21:461-468.

Hooper, R. G. 1977. Nesting habitat of common ravens in Virginia. Wilson Bulletin 89:233-242.

Hutto, R. L. 1995a. Composition of bird communities following stand-replacement fires in northern Rocky Mountain conifer forests. Conservation Biology. 9(5): 1041-1058.

Hutto, R. L. 1995b. U.S. Forest Service Northern Region songbird monitoring program: distribution and habitat relationships. U.S. Forest Service contract #R-95-05, Second Report, Northern Region, Missoula, Montana.

Hutto, R. L. 1996. An investigation of the potential threat of habitat fragmentation on some Northern region bird species. Final report for contract #53-0343-2-00207, Northern Region, Missoula, Montana. Institute for Wildlife Research National Wildlife Federation Scientific Technical Service No. 11.

Jensen, K. C. 1988. Nest site selection by bald eagles in Montana. Thesis, Montana State University, Bozeman. 56pp.

Johnson, R. F., Jr. 1976. Mortality factors affecting a white pelican population, Chase Lake National Wildlife Refuge, North Dakota. Michigan Technological Institute, Forestry Department.

Johnson, R. G., and S. A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management 54:106-111.

Jones, S. 1979. Habitat management series for unique or endangered species. Report No. 17. The accipiters: goshawk, Cooper's hawk, sharp-shinned hawk. Bureau of Land Management, Technical Note 335. 55pp.

Kaho, J. R. 1972. osprey management on the Lassen National Forest. Pages 7-13 *in* Cal-Nev wildlife: transactions. Wildlife Society, Smartsville, California.

Keller, M. E., and S. H. Anderson. 1992. Avian use of habitat configurations created by forest cutting in southeastern Wyoming. Condor 94:55-65.

Kelly, L. M., 1992. The effects of human disturbance on common loon productivity in northwestern Montana. Thesis, Montana State University, Bozeman. 65pp.

Klein, M. L., S. R. Humphrey, and H. F. Percival. 1995. Effects of ecotourism on distribution of waterbirds in a wildlife refuge. Conservation Biology 9(6):1454-1465.

Knick, S. T., and J. T. Rotenberry. 1995. Landscape characteristics of fragmented shrubsteppe habitats and breeding passerine birds. Conservation Biology 9:1059-1071.

Knight, R. L., and D. N. Cole. 1995. Wildlife responses to recreationists. Pages 51-69 *in* R. L. Knight , and K. J. Gutzwiller, editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D. C.

Knight, R. L., and K. J. Gutzwiller. 1995. Wildlife and recreationists: coexistence through management and research. Island Press. Washington, D. C.

Knight, R. L., and S. K. Skagen. 1988. Effects of recreational disturbance on birds of prey: a review. Pages 355-359 *in* Proceedings of Southwest raptor management symposium and workshop. Institute of Wildlife Research, National Wildlife Federal Science Technical Service No. 11.

Knight, R. L., and S. A. Temple. 1995. Wildlife and recreationists: coexistence through management. Pages 327-333 *in* R. L. Knight and K. J. Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, DC.

Korschgen, C. E., and R. B. Dahlgren. 1992. Human disturbances of waterfowl: causes, effects and management. USFWS. Fish and Wildlife Leaflet 13. Washington DC.

Korschgen, C. E., L. S. George, and W. L. Green. 1985. Disturbance of diving ducks by boaters in migrational staging areas. Wildlife Society Bulletin 13(3):290-6.

Krapu, G. L., and D. H. Johnson. 1990. Conditioning of sandhill cranes during fall migration. Journal of Wildlife Management. 54(2):234-238.

Kurvits, A. K. 1989. The impacts of nature tourism on wildlife: a case study of the peregrine falcon in the Northwest Territories. Thesis, York University, Ontario, Canada.

Kustich, J. 1999. An owl for all times. Montana Outdoor, March/April:20-24.

Levenson, H., and J. R. Koplin. 1984. Effects of human activity on productivity of nesting ospreys. Journal of Wildlife Management 48:1374-1377.

Lolo Forest Plan. 1986. U.S. Forest Service, Missoula, Montana.

Loos, G., and P. Kerlinger. 1993. Road mortality of saw-whet and screech-owls on the Cape May peninsula. Journal of Raptor Research 27:210-213.

Luckenbach, R. A. 1979. An analysis of off-road vehicle use on desert avifaunas. Forty-third North American Wildlife Conference:157-162.

Lynch, J. F., and D. F. Whigham. 1984. Effects of forest fragmentation on breeding bird communities in Maryland, USA. Biological Conservation 28:287-324.

Mahaffy, M. S., and L. D. Franzel. 1987. Elicited territorial responses of northern bald eagles near active nests. Journal of Wildlife Management 51:551-554.

Markham, B. J., and S. H. Brechtel. 1978. Status and management of three colonial waterbirds in Alberta. Proceedings of the Colonial Waterbird Group:55-64.

Massemin, S., and T. Zom. 1998. Highway mortality of barn owls in northeastern France. Journal of Raptor Research 32:229-232.

Mathisen, J. E. 1968. Effects of human disturbance on nesting bald eagles. Journal of Wildlife Management 32:1-6.

Mattise, S. N. 1995. Sage Grouse in Idaho: Forum '94. Idaho Bureau of Land Management Technical Bulletin No 95-15.

McClelland, B. R., L. S. Young, P. T. McClelland, J. G. Crenshaw, H. L. Allen, and D. S. Shea. 1994. Migration ecology of bald eagles from autumn concentrations in Glacier National Park, Montana. Wildlife Monograph 125. 61pp.

McEneaney, T. 1994. Status of the harlequin duck in Yellowstone National Park, Wyoming. P. 5 in Proc. 2nd annual harlequin duck symposioum, March 13-15, 1994. Harlequin Duck Working Group, 22pp.

McGarigal, K, R. G. Anthony, and F. B. Isaacs. 1991. Interactions of humans and bald eagles on the Columbia River Estuary. Wildlife Monoraph No. 115. 47pp.

McGarigal, K, and W. C. McComb. 1992. Streamside versus upslope breeding bird communities in the central Oregon coast range. Journal of Wildlife Management 56:10-23.

Miller, S. G., R. L. Knight, and C. K. Miller. 1998. Influence of recreational trails on breeding bird communities. Ecological Application 8:162-169.

Milling, T. C., M. P. Rowe, B. L. Cockerel, T. A. Dellinger, J. B. Gailes and C. E. Mill. 1997. Population densities of northern saw-whet owls *(Aegolius acadicus)* in degraded boreal forests of the southern Appalachians. Symposium Proceedings:Biology and Conservation of Owls of the Northern Hemisphere. U.S. Forest Service General Technical Report NC- 1 90: 272-285.

Millsap, B. A. 1987. Introduction to federal laws and raptor management . Pages 22-33 *in* B. A. Giron Pendleton, B. A. Millsap, K. W. Cline, and D. M. Bird, eds. Raptor management techniques manual. National Wildlife Federation, Scientific Technical Service No. 10. Washington, D. C.

Milne, K. A., S. J. Hejl. 1989. Nest-site characteristics of white-headed woodpeckers. Journal of Wildlife Management 53(1): 50-55.

Montana Bald Eagle Working Group (MBEWG). 1986. Montana bald eagle management plan. Bureau of Reclamation, Billings. 61pp.

MBEWG. 1991. Habitat management guide for bald eagles in northwestern Montana. U.S. Forest Service, Northern Region. 29pp.

MBEWG. 1994. Montana bald eagle management plan, second edition. Bureau of Reclamation, Montana Projects Office, Billings. 104pp.

Montana Bird Distribution Committe (MBDC). 1996. P. D. Skaar's Montana Bird Distribution, fifth edition. Special Publication No. 3. Montana Natural Heritage Program, Helena. 130pp.

Montopoli, G. J., and D. A. Anderson. 1991. A logistic model for the cumulative effects of human intervention on bald eagle habitat. Journal of Wildlife Management 55:290-293.

Moore, T. G., and M. Mangel. 1996. Traffic related mortality and the effects on local populations of barn owls. *In* Trends in Addressing Transportation Related Wildlife Mortality. Proceedings of the Transportation Related Wildlife Mortality Seminar. Florida Department of Transportation, Tallahassee, FL-ER-58-96.

Morrison, R G., and B. A. Harrington. 1979. Critical shorebird resources in James Bay and eastern North America. Transcript of North American Wildlife Natural Resource Conference 44:498-507.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermilion, South Dakota. 399pp.

Olson, C. 1999. Rough-legged hawks wintering in the Mission Valley, Montana. Thesis, University of Montana, Missoula.

Olson, S. L., and D. Edge. 1985. Nest site selection by mountain plovers in northcentral Montana. Journal of Range Management 38(3):280-282.

Paton, P. W. 1994. The effect of edge on avian nest success: how strong is the evidence? Conservation Biology 8:17-26.

Plumpton, D. L., and D. E. Andersen. 1998. Anthropogenic effects on winter behavior of ferruginous hawks. Journal of Wildlife Management 62(1):340-346.

Plumpton, D. L., and R. S. Lutz. 1993. Influence of vehicular traffic on time budgets of nesting burrowing owls. Journal of Wildlife Management 57:612-616.

Pokras, M. A., S. Rohrbach, C. Press, R. Chafel, C. Perry, and J. Burger. 1992. Environmental pathology of 124 common loons from the northeastern United States: 1989-1992. The Loon and its ecosystem: status, management and environmental concerns. 1992 American Loon Conference Proceedings, North American Loon Fund.

Postovit, H. R., and B. C. Postovit. 1987. Impacts and mitigation techniques. Pages 183-208 *in* B. A. Giron Pendeleton, B. A. Millsap, K.W. Cline, and D. M. Bird, eds. Raptor management techniques manual. National Wildlife Federation, Scientific Technical Service No. 10. Washington, D. C.

Pyke, C. 1997. Raptors and climbers: guidance for managing technical climbing to protect raptor nest sites. Access Fund, Boulder, Colorado.

Raphael, M. G., and M. White. 1976. Avian utilization of snags in a northern California coniferous forest. Unpublished report, on file with Pacific Northwest Research Station, Forestry and Range Sciences Laboratory, LaGrande Oregon. 27pp.

Redig, P. T., G. E. Duke, and P. Swanson. 1983. The rehabilitation and release of bald and golden eagles: a review of 245 cases. Pages 137-147 *in* D. M. Bird, ed. Biology and management of bald eagles and ospreys. Harpell Press, Ste. Anne de Bellevue, Quebec.

Reed, R. A., J. Johnson-Barnard, and W. L. Baker. 1996. Contribution of roads to forest fragmentation in the Rocky Mountains. Conservation Biology 10:1098-1106.

Reel, S., L. Schassberger and W. Ruediger. 1989. Caring for our natural community. Region 1, Threatened, Endgangered and Sensitive Species Program, USDA, Forest Service, Region 1, Missoula.

Reijnen, R., and R. Foppen. 1994. The effects of car traffic on breeding bird populations in woodland. I. Evidence of reduced habitat quality for willow warblers (*Phylloscopus trochilus*) breeding close to a highway. Journal of Applied Ecology 31:85-94.

Reijnen, R., R. Foppen, and H. Meeuwsen. 1996. The effects of traffic on the density of breeding birds in Dutch agricultural grasslands. Biological Conservation 75:255-260.

Reijnen, R., R. Foppen, E. T. Braak, and J. Thissen. 1995. The effects of car traffic on breeding bird populations in woodland. III. Reduction of density in relation to the proximity of main roads. Journal of Applied Ecology 32:187-202.

Restani, M. 1991. Resource partitioning among three *Buteo* species in the Centennial Valley, Montana. Condor 93:1007-1010.

Restani, M., and A. R. Harmata. 1993. Autumn concentration of bald eagles at Hauser Lake, Montana. 1992 Progress Report. Bureau of Land Management, Headwaters Res. Area, Butte, Montana. 43pp.

Reynolds, R. T. 1987. The status of accipiter populations in the western United States. Western Raptor Management Symposium and Workshop Proceedings. National Wildlife Federation. Washington, D. C.

Reynolds, R. T., R. T. Grahm, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce, G. Goodwin, R. Smith and E. L. Fisher. 1992. Management recommendations for the northern goshawk in the southwestern United States.

Rich, A. C., D. S. Dobkin, and L. J. Niles. 1994. Defining forest fragmentation by corridor width: the influence of narrow forest-dividing corridors on forest-nesting birds in southern New Jersey. Conservation Biology 8:1109-1121.

Richardson, C. T., and C. K. Miller. 1997. Recommendations for protecting raptors from human disturbance: a review. Wildlife Society Bulletin 25:634-638.

Riffell, S. K., K. J. Giutzwiller, and S. H. Anderson. 1996. Does repeated human intrusion cause cumulative declines in avian richness and abundance? Ecological Applications 6:492-505.

Rodgers, J. A., and H. T. Smith. 1995. Set-back distances to protect nesting-bird colonies from human disturbance in Florida. Conservation Biology 9(1):89-99.

Saab, V. A. 1996. Influences of spatial scale and land-use practices on habitat relationships of breeding birds in cottonwood riparian forests. Dissertation, University of Colorado, Boulder. Chapter 3:61-126.

Schumtz, J. K., and R. W. Fyfe. 1987. Migration and mortality of Alberta ferruginous hawks. Condor 89:169-174.

Schonewald-Cox, C., and M. Buechner. 1992. Park protection and public roads. Pages 373-395 *in* P.L. Fiedler and S. K. Jain, eds. Conservation Biology: the theory and practice of nature conservation, preservation, and management. Chapman and Hall, New York and London.

Schulz, T. A. 1986. The conservation and rehabilitation of the common barn owl *(Tyto alba).* Pages 146-166 *in* Association, P. Beaver, ed. Wildlife Rehabilitation, Fifth Symposium National Wildlife Rehabilitation. Boston, Massachusetts 5.

Sheffield, S. R. 1997. Current status, distribution, and conservation of the Burrowing Owl *(Speotyto cunitularia)* in midwestern and western North America. PAges 399-407 *in* Symposium Proceedings:Biology and Conservation of Owls of the Northern Hemisphere. U.S. Forest Service General Technical Report NC- 1 90.

Short, L. L. 1974. Habits and interactions of North American Three-toed Woodpeckers (*Picoides arcticus* and *Picoides tridactylus*). American Museum Novitates 2547.

Skaar, D. 1989. Montana common loon management plan. Flathead National Forest. Kalispell, Montana. 61pp.

Small, J. F., and M. L. Hunter. 1988. Forest fragmentation and avian nest predation in forested landscapes. Oecologia 76: 62-64.

Smith, D. G., J. R. Murphy, and N. D. Woffinden. 1981. Relationships between jackrabbit abundances and ferruginous hawk reproduction. Condor 83:52-56.

Snow, C. 1972. Habitat management series for endangered species. Report No. 1. American peregrine falcon and arctic peregrine falcon. Bureau of Land Management. 45pp.

Spackman, S. C., and J. W. Hughes. 1995. Assessment of minimum stream corridor width for biological conservation: species richness and distribution along mid-order streams in Vermont, USA. Biological Conservation 71:325-332.

Stalmaster, M. V. 1987. The bald eagle. Universe Books, New York, N. Y. 227pp.

Stalmaster, M. V., and J. R. Newman. 1978. Behavioral responses of wintering bald eagles to human activity. Journal of Wildlife Management 42(4):506-513.

Steenhof, K. 1987. Assessing raptor reproductive success and productivity. Pages 150-170 *in* B. A. Giron Pendeleton, B. A. Millsap, K.W. Cline, and D. M. Bird, eds. Raptor management techniques manual. National Wildlife Federation. Scientific Technical Service No. 10. Washington, D. C.

Storer, R. W. and G. L. Nuechterlein. 1992. Western and Clarks Grebe. *In* A. Poole, P. Stettenheim and F.Gill, eds. Birds of North America, No. 26. Philadelphia, Academy of Natural Sciences, American Ornithologists Union. Washington D.C.

Strauss, E. G. 1990. Reproductive success, life history patterns, and behavioral variation in a population of piping plovers subjected to human disturbance. Dissertation, Tufts University.

Strong, P. I. V. 1987. Reuse of nesting and nursery areas by common loons. Journal of Wildlife Management 51:123-127.

Suter, G. W., and J. L Jones. 1981. Criteria for golden eagle, ferruginous hawk, and prairie falcon nest site protection. Raptor Research 15:12-18.

Swenson, J. E. 1975. Ecology of the bald eagle and osprey in Yellowstone National Park. Thesis, Montana State University, Bozeman.

Thomas, J. W. 1979. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. U.S. Forest Service, Agriculture Handbook No. 553. 512pp.

Tremblay, J. and L. N. Ellison. 1979. Effects of human disturbance on breeding black-crowned night herons. Auk 96:364-369.

Trimble, S. A. 1975. Merlin *falco columbarius*. Bureau of Land Management Technical Note No. 15.

U.S. Fish and Wildlife Service (USFWS). 1986. Recovery plan for the Pacific bald eagle. USFWS, Portland, Oregon.

Van der Zande, A. N., J. C. Berkhuizen, H. C. van Latesteijn, W. J. ter Keurs, and A. J. Poppelaars. 1984. Impact of outdoor recreation on the density of a number of breeding bird species in woods adjacent to urban residential areas. Biological Conservation 30:1-39.

Van der Zande, A. N., W. J. ter Keurs, and W. J. van der Weuden. 1980. The impact of roads on the densities of four bird species in an open field habitat-evidence of a long-distance effect. Biological Conservation 18:299-321.

Vander Haegen, W. M. and R. M. DeGraff. 1996. Predation on artificial nests in forested riparian buffer strips. Journal of Wildlife Management 60: 542-550.

Varland, D. E., E. E. Klaas, and T. M. Loughin. 1993. Use of habitat and perches, causes of mortality and time until dispersal in post-fledging American kestrels. Journal of Field Ornithology 64(2):169-178.

Vos, D. K., R. A. Ryder, and W. D. Graul. 1985. Response of breeding great blue herons to human disturbance in northcentral Colorado. Colonial Waterbirds 8(1):13-22.

Wallen, R. L. 1987. Habitat utilization by harlequin ducks in Teton National Park. Thesis, Montana State University, Bozeman. 67pp.

Warkentin, I. G., and P. C. James. 1988. Trends in winter distribution and abundance of ferruginous hawks. Journal of Field Ornithology 59(3):209-214.

Wasser, S. K., K. Bevis, G. King, and E. Hanson. 1997. Non-invasive physiological measures of disturbance in the northern spotted owl. Conservation Biology 11:1019-1022.

Wershler, C. 1991. A management strategy for mountain plovers in Alberta. *In* Proceedings of the 2nd Endangered Species and Prairie Conservation Workshop. Regina, Saskatchewan, January 1989. Provincial Museum of Alberta Natural History Occasional Paper No 15.

White, C. M., and T. L. Thurow. 1985. Reproduction of ferruginous hawks exposed to controlled disturbance. Condor 87:14-22.

Woffinden, N. D., and J. R. Murphy. 1983. Ferruginous hawk nest site selection. Journal of Wildlife Management 47(1):216-219.
Woffinden, N. D., and J. R. Murphy. 1989. Decline of a ferruginous hawk population: a 20-year summary. Journal of Wildlife Management 53(4):1127-1132.
Wright, G. A., and D. W. Speake. 1977. Compatibility of the eastern wild turkey with recreational activities at Land Between the Lakes, Kentucky. Pages 578-584 *in* Proceedings of the Annual conference of the Southeastern Association of Fish and Wildlife Agencies.
Wright, M., and R. E. F. Escano. 1986. Montana bald eagle nesting habitat macro habitat description. U.S. Forest Service, Missoula, Montana. 24pp.
Yonge, K. S. 1981. The breeding cycle and annual production of the common loon (*Gavia immer)* in the boreal forest region. Thesis, University of Manitoba, Winnipeg. 131pp.
Zarn, M. 1975. Rough-legged hawk. Bureau of Land Management Technical Note 270. 23pp.

CHAPTER 4

SMALL MAMMALS

THE EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE
A Review for Montana

www.montanatws.org

MONTANA CHAPTER OF THE WILDLIFE SOCIETY

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ABSTRACT

Small mammal populations are a significant but often overlooked component of ecological communities. Small mammal populations although a key component of our ecosystems, have been little studied in comparison to other ecosystem components, and this is especially true in relationships to human disturbances. Based on the literature, it is apparent that recreationists affect wildlife through direct disturbance of normal activities. Decision-makers and natural resource managers are advised that any analysis of proposed changes in human activity should, as a first step, determine the sensitive species, keystone species, and sensitive habitats that may occur in the area under consideration. Information from the Montana Natural Heritage Program is used to highlight sensitive species and keystone species for Montana, and associate them with their particular habitats. Additionally, several of the more sensitive Montana habitats or environments are discussed in more detail, e.g. alpine habitats, bogs, subnivian environments, and bat habitats. Some specific and documented recreational impacts on small mammals are also discussed along with long-term and cumulative impacts. Guidelines and recommendations, based on the authors interpretation and synthesis of the available literature, are provided as well as the most urgent research and informational needs concerning recreational impacts to small mammals.

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When you try to change any single thing, you find it hitched to everything else in the universe.
~~ John Muir ~~

INTRODUCTION

Gutzwiller (1993) noted that numerous studies have shown that recreationists severely degrade habitat value for wildlife (Garton et al. 1977, Madsen 1985, Hammitt and Cole 1987, Blakesley and Reese 1988). Additionally, Boyle and Samson (1985) showed that even the most innocuous activities ". . . can cause displacement, detrimental changes in behavior and reproductive declines in wildlife." However, the most blatant intrusions are from off-road vehicle (ORV) use (Webb and Wilshire 1983). This chapter addresses some of the impacts of such recreation on small mammals, small mammal communities, and their habitats.

SMALL MAMMALS IN THE ECOSYSTEM

Small mammal populations are a significant but often overlooked component of ecological communities. Generally, small mammals fill most every ecological niche as herbivores, omnivores, and insectivores, and most form a vital prey base in the ecosystem. As herbivores they directly affect the composition and density of plants within their ranges, and as prey they represent a correspondingly important food base for many predators. Colonies of small mammals e.g., prairie dogs, ground squirrels, pocket gophers, etc., may serve as a significant prey base for local populations of raptors, owls, grizzly bears and other predators. As insectivores they are predators and consumers. Consequently, small mammals are an integral link in the structure of natural communities. Any changes in either small mammal density or diversity can have significant impacts and greatly affect the nature of the community. These changes in community structures commonly have ramifications far beyond the initial small mammal species affected and may start an ecological chain of events resulting in much broader ecological consequences. There is also the possibility that altered behavior of a keystone species could alter an ecosystem (Tomback and Taylor 1986, Knight and Cole 1991).

In deciding to allow increased human activity in an area the effects of that activity must be evaluated for any potential impacts to the natural communities where the activity will take place. Any analysis of potential impacts must take into consideration basic ecological principals. Communities are organized sets of interacting plant and animal species whose diversity varies greatly. Any human activity will cause some disturbance to that diversity and to the ecological community. Often the disturbance results in alteration of the patterns bye which energy and matter flow through ecosystems. Communities and species naturally vary in their tolerance for these disturbances, so it therefore becomes important to understand both species and habitat requirements as well as to identify those that are most sensitive to human activity.

SENSITIVE SPECIES AND SENSITIVE HABITATS

In any analysis of proposed changes in human activity, natural resource managers and decision makers should first determine the sensitive species, keystone species, and sensitive habitats that may occur in the area under consideration. Understanding the natural history and biology of certain keystone species (Gaines et al. 1992) is important in the development of management programs to conserve a larger portion of the entire community (Paine 1966, Gilbert 1980, Terborgh 1986, Simberloff 1988).

Several habitats are discussed in this chapter, but these are by no means the only sensitive habitats that should be considered. The habitats that are addressed are either more sensitive and/or are those that have been studied for possible recreational impacts. Use of these sensitive species and sensitive habitats as initial "yardsticks" may quickly determine the feasibility of a project or at least focus the in-depth analysis. Information on state species of special interest or concern, keystone species, and some accompanying habitat and distribution information can be obtained from the Montana Fish, Wildlife and Parks Nongame Program.

Species of Special Concern

The following small mammal information is from Flath (1998), and is found in *SPECIES OF SPECIAL INTEREST OR CONCERN* by the Montana Fish, Wildlife and Parks:

Preble's shrew (*Sorex preblei*): Occurs in low-density populations primarily in dry, shrubby habitats at lower elevations. Has been collected widely, from Silverbow to Valley counties and in central and south central parts of the state.

Dwarf shrew (*Sorex nanus*): Collected mostly from intrusive mountain ranges throughout central part of the state. Occurs in talus slopes and other well-drained sites at high altitudes such as the Beartooth Plateau. In mountain ranges like the Highwoods, occurs on steeper slopes, usually at higher elevations. Some specimens have been encountered at lower elevations.

Merriam's shrew (*Sorex merriami*): Occurs in low-elevation, shrub-grass habitats where sagebrush is present as a widely scattered species of low- or small-growth form. Wide distribution but an extremely rare species.

Northern long-eared bat (*Myotis septentrionalis*): Formerly Keen's myotis. Known only from the northeastern part of the state.

Fringed myotis (*Myotis thysanodes*): Very rare in Montana; near the northern edge of its range. Uses caves for roosts like other *Myotis*, but sometimes roosts behind loose bark of trees.

Spotted bat (*Euderma maculatum*): Reaches the northern edge of its range in Montana. Usually occurs in arid country where stock ponds and streams provide important foraging habitat.

Townsend's big-eared bat (*Plecotus townsendii*): A cave dweller for both maternity and hibernation purposes, primarily in the southwestern part of the state. Maternity colonies may be susceptible to human intrusion.

Pallid bat (*Antrozous pallidus*): Known from two captures and a single specimen near the Wyoming state line. Usually colonial.

Pygmy rabbit (*Brachylaqus idahoensis*): Known from Beaverhead, Madison, and Deerlodge counties. Occupies sagebrush habitats with loose friable soils.

Black-tailed jackrabbit (*Lepus californicus*): Known from Beaverhead County. Usually considered rare, but may be common in some years. Few recent sightings are known.

Uinta chipmunk (*Tamias umbrinus*): Occurs primarily in Yellowstone National Park and vicinity at higher elevations. Collected in southern Park County and may occur in southern Gallatin County as well. Specimens are needed from Buffalo Horn and vicinity to determine ecological relationship with *Tamoenus*.

Black-tailed prairie dog (*Cynomys ludovicianus*): Most recent (1998) population distribution is estimated at 66,139 acres. Former peak population distributed over 1.5 million acres during 1907-1914, but long-term historic population unknown. Current range same as former. Plague is a concern. Occupies level ground in short- and mid-grass prairie habitats. A "keystone" species. Management plan published.

White-tailed prairie dog (*Cynomys leucurus*): Found only in southern Carbon County in colonies totaling about 97 acres. Population apparently has not changed from historic level. This is the northern extent of its range in North America. Knowles (1999) stated ". . .there is a real possibility that the white-tailed prairie dog will be extirpated from Montana. . . ."

Great Basin pocket mouse (*Perognathus parvus*): A few specimens from Beaverhead County. Found in arid, short-grass sites with very limited shrub component.

Hispid pocket mouse (*Peroanathus hispidus*): A grassland species where sagebrush is scarce or absent. Known only from extreme southeastern Carter County.

Northern bog lemming (*Synaptomys borealis*): Only a few locations for this species have been documented. Found in high-altitude, wet meadow and bog habitats.

Meadow jumping mouse (*Zapus hudsonius*): occurs only in far eastern Montana. Very rare, but more sampling needed to determine status, distribution and habitat affinity.

Montana Natural Heritage Listings

As an additional resource, it is recommended that the *Montana Natural Heritage Program (MTNHP) be contacted for the latest listings of species and documented species distribution. MTNHP maintains lists of sensitive species and status of all species can be obtained from them or from the other 49 state or Canadian provincial Natural Heritage Programs. The various state and Canadian province natural heritage programs have been compiling and maintaining inventories of various elements of biological diversity within their jurisdictions. These inventories include plant species, animal species, plant communities, and other biological features that are rare, endemic, disjunct, threatened, or endangered throughout their range, those that are vulnerable to extirpation and those in need of further research. This represents the most comprehensive source for detailed information on rare and endangered species in North America. The current status for the vertebrates of Montana can be found in Appendix B.

There are five basic categories found in the status of species list (MTNHP 1999):

(1) **Global and State Ranks -** Ranks are assigned according to a standardized procedure used by all Natural Heritage Programs and represent one of the most powerful tools for the Natural Heritage Program. There are 7 rank categories that are applied to individual species on either a Global (G) or State (S) level. The seven categories are as follows:

(a) GX or SX: Extinct
(b) GH or SH: Possibly extinct
(c) G1 or S1: Critically imperiled
(d) G2 or S2: Imperiled
(e) G3 or S3: Vulnerable
(f) G4 or S4: Uncommon but secure
(g) G5 or S5: Common and secure

(2) **Federal Status** – Categories under the federal Endangered Species Act of 1973 (16 U.S.C. 1531-1543 (Supp. 1996) include endangered, threatened, proposed endangered, proposed threatened, or candidate under federal review for possible listing due to its biological vulnerability.

(3) **State Status -** Montana has 9 categories of legal status for vertebrates plus 2 management status as defined in The Nongame and Endangered Species Conservation Act (Mont. Code Ann. 87-5-101 1995).

(4) **Sensitive Species and Habitats (Table 4.1).** Small mammal watch species (+) and species of concern in Montana and habitats in which they are typically found. Rare or threatened habitats in Montana are asterisked.

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Table 4.1. Sensitive Species and Habitats

Species	Bog *	Short Grass Prairie	Sage-brush	Low shrub (non-sagebrush or minor sage component)	Alpine	Other High elev.	Caves & Mines	Brushy Woodland & Riparian	Conifer Forest	Canyons Cliffs or Rocky Areas
Preble's shrew			X	X				X		
Dwarf shrew		X	X	X	X	X			X	X
Merriam's shrew			X	X				X		
Northern long-eared bat				X			1	X	X	X
Fringed myotis			X	X			1		X	X
Spotted bat		X	X	X				X	X	X
Townsend's big-eared bat							2		X	X
Pallid bat		X					1	X	X	X
Pygmy rabbit			X							
Black-tailed jackrabbit			X	X						
Uinta chipmunk						X			X	
Black-tailed prairie dog		X								
White-tailed prairie dog		X	X	X						
Great Basin pocket mouse		X	X	X						
Hispid pocket mouse		X		X						X
Northern bog lemming	X								X	
Meadow jumping mouse								X		
+Yuma myotis			X	X			1	X	X	
+Eastern cottontail								X		
+Eastern spotted skunk								X		
+Western spotted skunk				X				X		

1 - some use of caves but not exclusive
2 - winters and breeds in Montana, uses caves exclusively for maternity and hibernation purposes

(5) **U.S. Forest Service Status -** The status of species on U.S. Forest Service (U.S.F.S.) lands as defined by the U.S.F.S. manual (2670.22). The Regional Forester (Northern Region) lists these taxa on national forests in Montana.

(6) **Bureau of Land Management Status -** The status of species on Bureau of Land Management (BLM) lands is defined by the BLM 6840 Manual.

MTNHP Watch List. The MTNHP maintains a species Watch List for species that meet one or more of the following criteria:

1. There are indications that the species may be less common than currently thought.
2. The species is currently declining in Montana or across much of their range.
3. There is so little information available that the species cannot adequately be ranked.
4. The species is not known to have established breeding populations in Montana, but is known from states/provinces near the border with Montana, and if the species occurs in Montana this would be a species of special concern.

Although not afforded any legal protection, these species should be treated with the same care as those designated as species of concern. As of January 1, 1999, all of the Watch List mammal species in Montana are small mammals and include:

Myotis yumanensis **Yuma Myotis (Vespertilionidae)**
Heritage Program Ranks: Global Rank: G5, State Rank: S3
Federal Agency Status: USFWS: – , USFS: – , BLM: –
State Agency Status: MT FW&P: Nongame Wildlife

Sylvilagus floridanus **Eastern Cottontail (Leporidae)**
Heritage Program Ranks: Global Rank: G5, State Rank: S2
Federal Agency Status: USFWS: –, USFS: –, BLM: –
State Agency Status: MT FW&P: Nongame Wildlife

Spilogale putorius **Eastern Spotted Skunk (Mustelidae)**
Heritage Program Ranks: Global Rank: G5, State Rank: SP
Federal Agency Status: USFWS: – , USFS: – , BLM: Special status
State Agency Status: MT FW&P: Unprotected

Spilogale gracilis **Western Spotted Skunk (Mustelidae)**
Heritage Program Ranks: Global Rank:G5, State Rank: SU
Federal Agency Status: USFWS: – , USFS: – , BLM: –
State Agency Status: MT FW&P: Unprotected

Alpine Habitats

Alpine habitats are ecologically sensitive and show significant impacts after minor use (HaySmith and Hunt 1995). The dry, cold climate; short growing season; and slow formation of new soil affect the time required for plant regeneration, making these habitats particularly fragile and susceptible to disturbance (Fitzgerald et al. 1994). In the Pacific Northwest, the greatest species diversity and richness of small mammals are found in the least fragile microhabitats in the alpine zone. These microhabitats, wet meadow, krummholz, or rock field, provide good cover and food availability (Reichel 1986). Disturbance from recreationists, however, may pose a threat in spite of microhabitat resilience. Some alpine small mammal species, such as the hoary marmot, are rare, except in national parks and wilderness areas (Hoffman and Pattie 1963), suggesting that they are intolerant of any human disturbance. Other, more broadly distributed species, such as chipmunks, may persist in areas of human disturbance, but nonetheless be threatened indirectly by human disturbance. If recreational activity displaces individuals from their home ranges, their susceptibility to predation may increase (Clarke et al. 1993).

Clark and Stromberg (1987) suggest that overgrazing by cattle in alpine meadows can have negative impacts on native small mammal species that rely on dense herbaceous vegetation for food and/or cover. Extensive human use of alpine meadows could have similar effects on alpine mammals. Reduced vegetation adjacent to talus slopes could reduce food for pikas and marmots, thus indirectly affecting their populations. Reduced meadow vegetation and litter could also reduce food and cover available to vole populations, especially *Microtus richardsonii*, which is dependent on lush sedge and forb vegetation along stream banks.

The greatest threat to alpine small mammals may be their isolation from one another. Alpine zones are arrayed as discontinuous islands along mountain ranges (Fitzgerald et al. 1994). Consequently, extinction and colonization rates of these sites are higher than elsewhere due to the insular nature of these habitats (Brown 1971). Populations of pikas and pocket gophers in these alpine islands are often distinct subspecies, pikas because of their exclusive use of talus and pocket gophers because of their lack of vagility. Local extinction of pikas or pocket gophers may represent irreplaceable genetic losses, and recolonization of isolated talus slopes after extinction may be difficult, if not impossible, for these species (Clark and Stromberg 1987).

Bogs

Bogs are another rare and ecologically fragile and rare habitat. Bogs develop on undrained or poorly drained sites where chemical conditions hinder decomposition of organic matter. These wetlands are characterized by standing water interspersed with vegetated ridges or floating mats of vegetation on organic soils (Hansen et al. 1995). Many bog plants and their associated animals, i.e., bog lemmings, are sensitive and specialized for existence on these distinctive habitats. In Montana, the northern bog lemming is classified as a rare species dependent on bogs or peatlands (Flath 1998, MTNHP 1999); several other small mammal species may be commonly associated with bogs.

Extensive use of bogs by ORVs could occur, in spite of the presence of standing water year-round. New “bog” and “swamp” vehicles capable of going through these areas are appearing on the market. In addition, snowmobile use on frozen bogs in winter and ORV use of trails passing through bogs could degrade these fragile habitats more than other recreational uses. The destruction of moss mats and other wetland vegetation and the soil compaction and associated reduction in invertebrate abundance and water quality (Cole and Landres 1995) could directly and indirectly affect small mammals, in particular bog lemmings and shrews, through habitat destruction, reduced food, and reduced cover. Trails and roads may divert or alter surface water flows, thus changing water levels and drainage patterns and significantly altering the unique bog habitat. Trail management aimed at reducing impacts of foot and horse traffic through bogs may be inadequate to compensate for impacts of ORVs and may require modification in areas with high ORV use.

Wanek (1973) reported on the effects of snowmobiling on bog plants in northern Minnesota. He found that in bog communities that snowmobiling caused a delay in the spring thaw by as much as 2 weeks due to deeper frost penetration. Even though he found that snowmobile impacts on sphagnum moss were negligible, herbs and shrubs showed declines directly related to the intensity of snowmobile traffic. Bog plants were affected both by physical damage and from the results of cold temperatures, which caused severe physical damage, retarded growth, desiccation, or death.

Subnivian Environments

Snow cover is important to the overwinter survival of many species because of the protection that the subnivian environment provides from the stresses of direct exposure to severe winter weather and predation (Formozov 1946, Pruitt 1957 and 1970, Fuller 1969). Consequently, the use of snowmobiles should take the subnivian environmental requirements of small mammals into consideration. Snow packing by snowmobile use reduces the insulating value of the snow; increases mechanical barriers to small mammal movements beneath it. According to Boyle and Samson (1985) has caused significant damage to browse plants. Jarvinen and Schmid (1971) found that snowmobile compacted snowfields increased the winter mortality of small mammals. They indicated that compaction inhibited mammal movements beneath the snow and subjected subnivian organisms to greater temperature stress. Furthermore, Neumann and Merriam (1972) showed that snowmobile use in Ontario caused significant changes in snow structure and, subsequently, wildlife behavior. Snowmobiles affected snowshoe hare and red fox mobility and distribution and caused serious damage to browse plants.

Bury’s (1978) analysis of snowmobile impacts on wildlife concluded that the major effects of snowmobiles on most wildlife species appeared to be “changes in the animals’ daily routine, rather than direct mortality.” For small mammals, this was found to be the case for rabbits by Baldwin and Stoddard (1973). For subnivian small mammals, “. . . experimental manipulation of a snowfield has shown that the mortality of small mammals is markedly increased under snowmobile compaction” (Schmid 1972). A number of researchers (Mezhzherin 1964, Schwartz et al. 1964, Fuller 1969, Fuller et al. 1969, Brown 1971) have shown that small mammals experience reduced growth during the winter. Jarvinen and Schmid (1971) stated, “The colder temperatures of winter seem to be stressful to small mammals, even if moderated by snow cover.” Small mammals under this type of stress are certainly more vulnerable to the added impacts of snowmobile usage. Obviously, as the population of small mammals is reduced, the populations of predators that prey on them (e.g. foxes, weasels, hawks, owls, etc.) may also be reduced (Brander 1974).

Bat Habitats

Other than cave exploration or "spelunking," the effects of recreation on bats is not well understood. Likewise, the literature on this topic is also limited. However, we can infer some potential threats to bats from recreation, based on available information regarding bat biology and ecology. The most important manner in which human activity is likely to impact bats is the direct disturbance of bats in maternal or hibernacula roosts. These are during periods when it is crucial that bats conserve energy.

The sensitivity of bats to human disturbance of roost sites is well documented (Pearson et al. 1952, Graham 1966, Stebbings 1966, Mohr 1972, Humphrey and Kunz 1976, Stihler and Hall 1993, Pierson and Rainey 1994). Unfortunately for the bats, caving as a recreational activity is increasing. Membership in the National Speleological Society increased by approximately 28% from 1991 to 1995 and now has a membership of more than 11,000. Although most active cavers support the conservation of caves and cave resources and they exercise caution so as not to disturb roosting bats, there is still a degree of negative impact to bats from increased visitation by humans (ISCE 1995).

Caves visited by humans during stressful periods for bats (e.g. hibernation and rearing of young) have shown population declines in some bat species such as Townsend's big-eared bat. In some instances, visitations may result in roost abandonment (Graham 1966). Pierson and Rainey (1994) have shown that bat colonies that experienced the most severe population declines had a high rate of visitations by humans. Excluding human use from sensitive bat roosting sites can help recover populations that have been reduced by disturbance. However, when such exclosures fail or are breached, bat populations typically drop rapidly and recovery is slow (Stihler and Hall 1993).

Sadly, some damage to roosting bats is intentional. There have been recorded incidents of arson-related mine fires that resulted in the loss of thousands of bats as well as incidents of individuals using high-powered rifles to shoot bats at a roost site (ISCE 1995). While these types of actions are not common, misunderstanding and misinformation about bats are still fairly prevalent and will undoubtedly result in the continuation of intentional harm to bats on the part of some recreationists.

An indirect impact of human recreation on bat populations stems from land management agencies concerns for public safety at abandoned mines. Bats are increasingly using abandoned mines and other structures such as culverts and old buildings for roost sites. This may be due, in part, to increased human interest in cave recreation and the loss of other natural cavities such as those previously found in large, old trees. Because abandoned mines and old structures can be dangerous for humans, there has been an on-going effort to close down abandoned mines and to remove old buildings and culverts that have fallen into disuse. Closure of mines and destruction of buildings and culverts can result not only in direct mortality of bats if the structures are occupied at the time of closure, but also may indirectly result in elimination of potential bat habitat if the sites are not already occupied (ISCE 1995). Displaced bats may be unable to find alternative suitable roost sites because structures providing temperature and humidity conditions in their narrow range of tolerance are rare (Mohr 1976). Any loss of roosting habitat poses a threat to the persistence of bats in an area.

Expanding human access to remote locations also increases the probability of conflicts between bats and humans as the locations of additional roost sites become known. Motorized recreation at night may interfere with bats' ability to effectively use echolocation for communication, navigation, and prey detection; such interference was observed near running water (Mackey and Barclay 1988). Roads, because of coincident noise, likely reduce the quality of roosting habitat nearby (Harvey 1980).

Public education that emphasizes the beneficial aspects of bats as well as debunk old myths that are still prevalent serve to help minimize negative human impacts on bats. In addition, high priority should be given to properly gating abandoned mine shafts in an manner that allows continued use by bats while protecting human safety.

RECREATIONAL IMPACTS ON SMALL MAMMALS

August et al. (1979) stated, "Demographic patterns of small mammals can be useful in determining the effects of human use upon a given area. Comparisons of populations before and after periods of human use reveal changes associated with the use which may serve as a measure of disturbance" Bury et al. (1977) demonstrated the direct impact of ORVs on species richness, abundance, and biomass. Areas of ORV use have significantly fewer species of vertebrates, greatly reduced abundance of individuals, and noticeably lower small mammal biomass. Bury et al. (1977) also showed that diversity, density, and biomass of small mammals are inversely related to the level of ORV use in an area.

The impacts of ORV use on small mammals is more directly related to the impacts on vegetation and barriers created by trails and roads. Knight and Cole (1991), "Recreational activities…result in habitat modification by disturbing the vegetation and soil, and changing microclimates." These vegetative impacts would be most severe in sensitive alpine areas, bogs, and arid regions. The Northern bog lemming is an example of a sensitive species and a species of special concern occurring in bog habitats. In Montana, there have only been a few locations documented for this species, and these include high-altitude wet meadow and bog habitats. Consequently, any activities contemplated for these habitats should be carefully managed and researched thoroughly.

For some species of small mammals, just the presence of humans may have adverse impacts. For example, Mainini et al. (1993) studied the reactions of marmots (*Marmota marmota*) to the impacts of tourist activities in alpine areas and that stated, "In alpine regions the marked increase in. . . tourist activities could reduce the success of individual animals and in the longer term threaten the existence of animal populations or even species." In this study, they found that even the presence of hikers could have a negative impact on foraging.

Recreational shooting is another area of concern that managers need to be aware of. In Montana the estimated area occupied by black-tailed prairie dogs (*Cynomis ludovisianus*) has declined from 1.7 million acres in 1914 to 66,139 acres in 1998, a decrease of more than 96%. This decline is due to rapidly diminishing habitats, poisoning and trapping campaigns, plague, and shooting. Shooting has been shown to have significant effects on prairie dog populations (Fox and Knowles 1995, Knowles 1995, Vosgurgh and Irby 1998). On one 12,000-acre portion of a South Dakota prairie dog town, shooters killed approximately 75% of an estimated 216,000 prairie dogs in 1998 (NWF1998). This level of shooting can have serious ramifications for small mammals and other fauna that are dependent on or favor prairie dog town habitat, such as burrowing owls, black-footed ferrets, badgers, mountain plovers, and rattlesnakes. Burrowing owls, black-footed ferrets, and mountain plovers are all federally listed species. Recreational shooting for other species considered by some to be "varmints" is common in many areas and can have similar results. Any program that allows or encourages recreational shooting of small mammals should include a serious analysis of the potential effects, both direct and indirect to other species.

Table 4.2. Recreational Impacts on Small Mammals of Concern. Some potential effects have no literature citations. In our best professional judgement, derived from a synthesis of the literature, these are probable impacts and are indicative of a research need rather than a lack of impact.

INFLUENCE	EFFECT	LITERATURE REVIEW
Snow-machines	Direct mortality	**Small Mammals:** Bury '78, Schmid '72
	Population reduction	**Small Mammals:** Schmid '72
	Energy expenditure due to disturbance	**Small Mammals**
	Displacement	**Small Mammals:** Baldwin & Stoddard '73
	Habitat modification including change in microclimate	**Small Mammals:** Schmid '72
	Forage removal	**Small Mammals:** Boyle & Samson '85
	Cover removal	**Small Mammals:** Boyle & Samson '83
Caving	Direct mortality	**Bats:** Idaho State Conservation Effort '95
	Population reduction	**Bats:** Pierson & Rainey '94, Stihler & Hall '93
	Energy expenditure due to disturbance	**Bats:** Pearson et al. '52, Graham '66, Stebbins '66, Mohr '72, Humphrey & Kuntz '76, Stihler & Hall '93, Pierson & Rainey '94, Idaho State Conservation Effort '95
	Displacement	**Bats:** Graham '66
	Habitat modification including change in microclimate	**Bats**
Road Use	Direct mortality	**Small Mammals**
	Energy expenditure due to disturbance	**Bats:** Harvey '80
	Forage removal	**Small Mammals**
	Cover removal	**Small Mammals**
	Interference with echolocation	**Bats:** Harvey '80
ORV Use	Population reduction	**Small Mammals:** Bury et al. '77
	Energy expenditure due to disturbance	**Bats:** Harvey '80
	Habitat modification including change in microclimate	**Small Mammals:** Cole & Landres '95
	Forage removal	**Small Mammals:** Knight & Cole '91
	Cover removal	**Small Mammals:** Knight & Cole '91
	Interference with echolocation	**Bats:** Harvey '80
Other Motorized Activity or Blasting+	Energy expenditure due to disturbance	**Bats and other Small Mammals**
	Displacement	**Bats and other Small Mammals**
	Habitat modification including change in microclimate	**Bats**
	Interference with echolocation	**Bats:** Harvey '80
Hiking and Backpacking	Energy expenditure due to disturbance	**Small Mammals:** Pater '98, Mainini et al. '93, Knight & Cole '91, Graevskaya et al. '88, Smith & Woodruff '80, Bolinger '74, Hoffman & Searle '68, Hoffman & Pattie '63, Anthony & Ackerman '55,
	Displacement	**Small Mammals:** Pater '98, Clarke et al. '93, Mainini et al. '93, Graevskaya et al. '88, Smith & Woodruff '80, Brander '74, Hoffman & Searle '68, Anthony & Ackerman '55,
	Habitat modification including change in microclimate	**Small Mammals:** Clark & Stromberg '87
	Forage removal	**Small Mammals:** Clark & Stromberg '87
	Cover removal	**Small Mammals:** Clark & Stromberg '87
Recreational Shooting	Direct mortality	**Prairie Dogs:** Fox & Knowles '95, Knowles '95, Vosburgh & Irby '88; **Small Mammals**
	Population reduction	**Prairie Dogs:** Fox & Knowles '95, Knowles '95, Vosburgh & Irby '88; **Small Mammals**
	Energy expenditure due to disturbance	**Small Mammals**
Cumulative Effects	Population reduction	**Small Mammals:** Knight & Cole '91, Hutchins & Geist '87
	Energy expenditure due to disturbance	**Small Mammals:** Hutchins & Geist '87
	Displacement	**Small Mammals:** Knight & Cole '91, Phelps & Hatter '77, Klein '71

+ this refers to blasting that may occur for road or trail improvement or construction (peripherally related to recreation)

* this activity is most relevant for black-tailed prairie dog and white-tailed prairie dog

CUMULATIVE AND LONG-TERM EFFECTS

Bell and Austin (1985) state, "Recreational activities should not be viewed in isolation. There may be synergisms or interactions when more than one recreational activity is occurring simultaneously. . . ." The timing and frequency of disturbances may also have long-term effects. Many responses exhibited by small mammals to recreationists may be short-lived. However, there may also be long-term and cumulative effects of repeated disturbances that are important but not immediately obvious. Effects often include abandonment of disturbed areas (response-avoidance) in favor of undisturbed sites or in some cases attraction to recreational activities (Klein 1971, Phelps and Hatter 1977, Knight and Cole 1991). Either response may lead to behavioral alterations in mating, feeding, predator avoidance, or other behaviors. Knight and Cole (1991) state, "Disturbance can also reduce the vigor of individuals and ultimately result in death. Elevated heart rates, energy expended in disturbance flights, and reductions of energy input through disturbance will all increase energy expenditures or decrease energy acquisition. These may result in increased sickness, disease and potentially death of individuals. While these responses have been suggested, evidence is largely circumstantial (e.g., Hutchins and Geist 1987)."

Responses of small mammals to disturbance can be characterized through measurement of proximal effects, that is the direct and immediate response of the mammal to the stimulus of human activity. A proximal effect could be a behavioral (e.g. flight) or a physiological (e.g. change in heart rate) response (Anthony and Ackerman 1955, Bolinger 1974, Graevskaya et al. 1988, Hoffman and Searle 1968, Smith and Woodruff 1980, Mainini et al. 1993, Pater 1998). Experience with humans and animals has shown that the dose-response relationship is typically different for each type of activity (Pater 1998). However, there is still much to be learned about these proximal effects and their cumulative and long-term effects.

There have been few studies considering habituation (the reduction of severity of both physiological and behavioral responses) when small mammals become accustomed to human activities. It is likely that in many cases small mammals rapidly become habituated to recreational activities, and the impacts may prove to be inconsequential. Adaptations, on the other hand, may require multiple generations. Consequently, until more detailed studies can be done, prudence would dictate that we adopt a conservative approach to the impacts of recreation.

CONCLUSION

Small mammal populations, although a key component of our ecosystems, have been little studied in comparison to other ecosystem components. This is especially true in relationships to human disturbances. Consequently, there is a correspondingly limited body of literature related to either direct or indirect effects of human disturbances on small mammals. However, it has been shown that, "Recreational activities can result in habitat modification by disturbing the vegetation and soil, and changing microclimates. . . [and] . . .recreational activities can impact abundance, distribution and demographics of populations" (Knight and Cole 1991). Luckenbach (1975) has stated, "Opening vast areas to ORV use with a qualification such as using existing trails and roads is largely unmanageable."

Based on the literature it is apparent that recreationists affect wildlife through direct disturbance of normal activities (Knight and Cole 1991). "Disturbances can be intentional (e.g., harassment) or unintentional. Unintentional disturbance may include such things as attempting to photograph wildlife, naturalists viewing nesting birds, or hikers crossing an animal's territory. Bury (1978) has shown that ". . .snowmobiles crush small mammals that inhabit the subnivian space between snow and ground. Knight and Cole (1991) also point out that "unintentional disturbance is probably the primary means by which nonconsumptive recreational activities impact wildlife."

RECOMMENDATIONS/GUIDELINES

These guidelines are based on our interpretation and synthesis of the available literature. The proposed guidelines have been conservatively developed to protect sensitive species and habitats from both known and potentially significant impacts:

1. Managers should identify any sensitive species, their distribution, and required habitat requirements that may occur in the areas of proposed recreational activities and should further consider restrictions to minimize, eliminate, or prevent direct effects from recreational disturbances.
2. Managers should identify those sensitive habitats that may occur in an area and should make efforts to minimize, eliminate or prevent recreational activities in or near those areas.
3. Managers should strive to identify the indirect as well as the direct impacts that activities may have on the ecosystem, such as changes in plant and animal diversity and density, alteration of hydrology, changes in predator prey ratios, introduction of invasive species, etc.
4. Managers should limit human activities close to natural caves, tunnels, and mines where there may be bat nurseries or hibernacula.
5. Managers should consider control of pets around campgrounds, trails, and other recreational settings.

INFORMATIONAL NEEDS

Ecological changes that result from recreational users may take a long time to become apparent (Schmidly and Ditton 1978). There is a large gap in our knowledge of what those changes may be and their ecological consequences. The following list summarizes, in our professional judgement, the most urgent research and informational needs:

1. Determination of both the direct and indirect impacts of recreational activities upon small mammals.
2. Identification of sensitive habitats and development of an understanding of the importance of specific habitats to small mammals and the consequences of human activities upon those habitats.
3. Characterization of the relationship or “place” of small mammals in the ecosystem and the ecological impacts of alterations to small mammal densities and diversity.
4. Assessment of the impacts of unintentional or nonconsumptive recreational activities upon small mammals and their essential habitats.
5. Interpretation of the critical long term and cumulative effects of recreational activities on small mammals and their required habitats e.g., level of activities, frequency of activities, impacts of multiple activities, timing of activities, etc.
6. Evaluation of the role that recreational activities have on physiological responses such as, reduced vigor of individuals, elevated heart rates, increased energy expenditures, induced disturbance flights, or reduced energy input through disturbance. It is important to know how any or all of these factors may further increase energy expenditures, decrease energy acquisition, and/or result in death.
7. Consideration is needed to further analyze and understand the proximal effects recreational impacts have on altering small mammal behavior and subsequent individual and population impacts.

LITERATURE CITED

Anthony, A., and E. Ackerman. 1955. Effects of noise on the blood eosinophil levels and adrenals of mice. Journal of the Acoustical Society of America. 27(6):1144-1149.

August, P. V., J. W. Clarke, M. H. McGaugh, and R. L. Packard. 1979. Demographic patterns of small mammals: A possible use in impact assessment. Pages 333-340 *in* Genoways, H. H., Baker, R. J., editors Biological investigations in the Guadelupe Mountains National Park, Texas. Symposium Proc. Trans. Ser. 4; 1975 Apr 4-5; Lubbock, Texas. U. S. Natl. Park Serv.

Baldwin, M. F., and D. H. Stoddard, Jr. 1973. The off-road vehicle and environmental quality, 2nd ed. The Conservation Foundation, Washington, D.C. 6pp.

Bell, D. V., and L. W. Austin. 1985. The game-fishing season and its effects on overwintering wildfowl. Biological Conservation 33:65-80.

Bennett, A. F. 1991. Habitat corridors and the conservation of small mammals in a fragmented forest environment. Landscape Ecology 4:109-122.

Blakesley, J. A., and K. P. Reese. 1988. Avian use of campground and non-campground sites in riparian zones. Journal of Wildlife Management. 52:399-402.

Bolinger, J. 1974. Effect of snowmobile noise on deer and rabbits in their natural habitat. Ed. Proc. of the 1973 snowmobile and Off the Road Vehicle Research Symposium. E. Lansing, MI, Michigan State University, Dept. Park Recr. Resources, Tech Report 9.

Boyle, S. A., and F. B. Samson. 1985. Effects of nonconsumptive recreation on wildlife: A review. Wildlife Society Bulletin. 13:110-116.

Brander, R. B. 1974. Ecological impacts of off-road recreational vehicles. Pages 29-35 *in* U.S. Forest Service, North Central Experiment Station. Outdoor recreation research: applying the results. Papers from a workshop held by the USDA Forest Service at Marquette, Michigan, June 19-21, 1973. U.S. Government Printing Office, Washington, D.C.

Brown, E. B. 1971. Some aspects of the ecology of the small, winter-active mammals of a field and adjacent woods in Itasca State Park, Minnesota. Ph.D. thesis. University of Minnesota, Minneapolis. 173pp.

Bury, R. L. 1978. Impacts of snowmobiles on wildlife. Transactions North American Wildlife and Natural Resource Conference. 43:149-156.

Bury, R. B., R. A. Luckenbach, and S. O. Busack. 1977. Effects of off-road vehicles on vertebrates in the California Desert. Washington, D. C., Fish and Wildlife Service. Pp. 1-23. Wildlife Research Report 8.

Clark, T. W., and M. R. Stromberg. 1987. Mammals in Wyoming. University of Kansas, Museum of Natural History, Lawrence, Kan. 314pp.

Clarke, M. F., K. B. da Silva, H. Lair, R. Pocklington, D. L. Kramer, and R. L. McLaughlin. 1993. Site familiarity affects escape behavior of the eastern chipmunk, *Tamias striatus*. Oikos 66:533-537.

Cole, D. N., and P. B. Landres. 1995. Chapter 11. Indirect effects of recreationists on wildlife. Pages 183-202 *in* R. L. Knight and K. J. Gutzwiller, editors Wildlife and Recreationists. Island Press, Washington, D.C.

Fitzgerald, J. P., C. A. Meaney, and D. M. Armstrong. 1994. Mammals of Colorado. University Press of Colorado, Niwot, Colo. 467pp.

Flath, D. L. 1998. Species of Special Interest or Concern. Montana Fish, Wildlife and Parks. Helena, Montana.

Formozov, A. N. 1946. The covering of snow as an integral factor of the environment and its importance in the ecology of mammals and birds. Material for fauna and flora of USSR, New Series, Zoology, 5:1-152. (English ed., occasional paper no. 1, Boreal Institute, Univ. Alberta, Edmonton, Alberta, Canada. 197 pp.)

Fox, M., and C. J. Knowles. 1995. An economic and ecological evaluation of the fort Belknap Indian Reservation fish and wildlife program. Poster presented at the 1995 annual meeting of the Montana Wildlife Society.

Fuller, W. A. 1969. Changes in numbers of three species of small rodents near Great Slave Lake, N.W.T., Canada, 1964-1967, and their significance for general population theory. Ann. Zool. Fennici, 6:113-144.

Fuller, W. A., L. L. Stebbins and G. R. Dyke. 1969. Overwintering of small mammals near Great Slave Lake, northern Canada. Arctic. 22:34-55.

Gaines, M. S., G. R. Robinson, J. E. Diffendorfer, R. D. Holt, and M. L. Johnson. 1992. The effects of habitat fragmentation on small mammal populations. In D. R. McCullough and R. H. Barret, editors, Wildlife 2001: Populations. In press.

Garton, E. O., B. Hall, and T. C. Foin, Jr. 1977. The impact of a campground on the bird community of a lodgepole pine forest. Pages 37-43 *in* R. C. Foin, Jr. Ed., Visitor impacts on national parks: The Yosemite ecological impact study. Publ. 10, Inst. Ecol., Univ. California, Davis. 99pp.

Gilbert, L. E. 1980. Food web organization and the conservation of neotropical diversity. Pages 11-33 *in* Soule, M. E., and Wilcox, B. A., editors, Conservation Biology: An Evolutionary-Ecological perspective. Sinauer. Sunderland, MA.

Graevskaya, B. M., N. N. Zolotareva, S. S. Elfimova, and N. I. Malishevskaya. 1988. Reaction of Metabolism of Rodents as an Indicator of Response to the Effect of an Anthropogenic Milieu. Sov. Journal Ecology 19(2):110-114.

Graham, R. E. 1966. Observations on the roosting habits of the big-eared bat, *Plecotus townsendii* in California limestone caves. Cave Notes. 8:17-22.

Gutzwiller, K. J. 1993. Serial Management Experiments: An Adaptive Approach to Reduce Recreational Impacts on Wildlife. Transactions 58th North American Wildlife & Natural Resources Conference. Pp:528-536.

Hammitt, W. E., and D. N. Cole. 1987. Wildland recreation: Ecology and management. John Wiley and Sons, New York, New York. 341pp.

Hansen, P. L., R. D. Pfister, K. Boggs, B. J. Cook, J. Joy, and D. K. Hinckley. 1995. Classification and management of Montana's riparian and wetland sites. Montana Forest and Conservation Experiment Station Misc. Pub. No.54, pp.19-20.

HaySmith, L., and J. D. Hunt. 1995. Chapter 12. Nature tourism: impacts and management. Pages 203-219 *in* R. L. Knight and K. J. Gutzwiller, editors Wildlife and Recreationists. Island Press, Washington, D.C.

Hoffman, H. S., and J. L. Searle. 1968. Acoustic and temporal factors in the evocation of startle. J. of the Acous. Soc. Of Am. 43(2):269-282.

Hoffman, R. S., and D. L. Pattie. 1963. A guide to Montana mammals: identification, habitat distribution and abundance. University of Montana, Missoula, Montana. 133pp.

Humphrey, S. R. And T. H. Kunz. 1976. Ecology of a Pleistocene relict, the western big-eared bat (*Plecotus townsendii*), in the southern Great Plains. Journal of Mammalogy. 57:470-494.

Hutchins, M., and V. Geist. 1987. Behavioral considerations in the management of mountain-dwelling ungulates. Mount. Res. Develop. 7:135-144.

Idaho State Conservation Effort (ISCE). 1995. Habitat conservation assessment and conservation strategy for the Townsend's big-eared bat. Draft unpublished. Report No. 1. Boise, Idaho.

Jarvinen, J. A., and W. D. Schmid. 1971. Snowmobile use and winter mortality of small mammals. Pages 130-140 *in* M. Chubb, ed. Proceedings of the 1971 snowmobile and off the road vehicle research symposium. Tech. Rep. No. 8, Recreation Research and Planning Unit, Dep. Park and Recreation Resources. Michigan State University, East Lansing. 196pp.

Klein, D. R. 1971. Reaction of reindeer to obstructions and disturbance. Science 173:393-398.

Knight, R. L., and D. N. Cole. 1991. Effects of Recreational Activity on Wildlife in Wildlands. Transactions of the 56th North American Wildlife & Natural Resources Conference. Pp: 238-247.

Knowles, C. J. 1995. A summary of black-tailed prairie dog abundance and distribution on the central and northern great plains. Report to Defenders of Wildlife, Missoula, Montana 59801. 62pp.

Knowles, C. J. 1999. Status of the black and white-tailed prairie dogs in Montana. Report to Montana Fish, Wildlife and Parks, Helena, Montana 59620. 34pp.

Luckenbach, R. A. 1975. What the ORVs are doing to the desert. Fremontia 2:3-11.

Mackey, R. L., and M. R. Barclay. 1989. The influence of physical clutter and noise on the activity of bats over water. Canadian Journal of Zoology 67:1167-1170.

Madsen, J. 1985. Impact of disturbance on field utilization of pink-footed geese in West Jutland, Denmark. Biological Conservation 33:53-63.

Mainini, B., P. Neuhaus, and P. Ingold. 1993. Behavior of Marmots *Marmota marmota* under the influence of different hiking activities. Biological Conservation 64:161-164.

Mezhzherin, W. A. 1964. Dehnel's phenomenon and its possible explanation. Acta Theriologica, 8:95-114. (In Russian, English summary).

Mohr, C. E. 1972. The status of threatened species of cave-dwelling bats. Bull. of the Nat. Speleol. Soc. 34:33-37.

Montana Natural Heritage Program (MTNHP). 1999. Helena, Montana.

National Wildlife Federation. 1998. Petition for rule listing the black-tailed prairie dog (*Cynomis ludovicianus*) as threatened throughout its range. Petition to the USF&WS, National Wildlife Federation, Vienna, Virginia. 66pp.

Neumann, P. W., and H. G. Merriam. 1972. Ecological Effects of Snowmobiles. Canadian Field-Naturalist, 86:207-212.

Paine, R. T. 1966. Food web complexity and species diversity. American Naturalist. 110:107-119.

Pater, L. 1998. Noise Impacts on Animals: Methodology. Fish & Wildlife News, The National Military Fish and Wildlife Association. 16(3): 4.

Pearson, O. P., M. R. Koford, and A. K. Pearson. 1952. Reproduction of the lump-nosed bat (*Corynorhinus rafinesquei*) in California. Journal of Mammalogy 33:273-320.

Phelps, J. E. and J. Hatter. 1977. The Effects of Campgrounds on Small Mammals in Canyonlands and Arches National Parks, Utah. Forty-second North American Wildlife Conference. Pp:473-485.

Pierson, E. D. And W. E. Rainey. 1994. The distribution, status and management of Townsend's big-eared bat (*P. townsendii*) in California. Report to California Department of fish and Game, Sacramento, CA. 48pp.

Pruitt, W. O., Jr. 1957. Observations on the bioclimate of some taiga mammals. Arctic, 10:130-138.

Pruitt, W. O., Jr. 1970. Some ecological aspects of snow. In: Ecology of the subarctic regions, Proceeding of the Helsinki Symposium. UNESCO, Place de Fontenoy, 75 Paris - 7, France. 364pp.

Reichel, J. D. 1986. Habitat use by alpine mammals in the Pacific Northwest, USA. Arctic and Alpine Research 18:111-119.

Schmid, W. D. 1972. Snowmobile activity, subnivian microclimate and winter mortality of small mammals. Abstract of paper presented at 1972 meeting, American Institute of Biological Scientists, University of Minnesota. Bull. Ecol. Soc. Amer. 53(2):37.

Schwartz, S. S., A. V. Pakrovski, V. G. Istchenko, V. G. Olsnjev, N. A. Ovtschinnikov, and O. A. Pjastolova. 1964. Biological peculiarities of seasonal generations of rodents with special reference to the problem of senescence in mammals. Acta Theriologica, 8:11-43.

Simberloff, D. 1988. The contribution of population and community biology to conservation science. Ann. Rev. Ecology and Systematics 19:473-511.

Smith, A. T., and M. L. Watson. 1990. *Ochotona princeps*. Mamm. Species No. 352. Am. Soc. Mamm. 8pp.

Smith, E. N., and R. A. Woodruff. 1980. Fear bradycardia in free-ranging woodchucks (*Marmota monax*). J. of Mammalogy. 61:750-753.

Stebbings, R. E. 1966. Bats under stress. Studies in Speleology. 1(4):168-173.

Stihler, C. W., and J. S. Hall. 1993. Endangered bat populations in West Virginia caves gated or fenced to reduce human disturbance. Bat Research News. 34(4):130.

Terborgh, J. 1986. Keystone plant resources in the tropical forest. Pages 330-334 *in* M. E. Soule and B. A. Wilcox, editors, Conservation Biology. Sinauer, Sunderland, Massachusetts. 584pp.

Tomback, D. F., and C. L. Taylor. 1986. Tourist impact on Clark's nutcracker foraging activities in Rocky Mountain National Park. Pages 158-172 *in* F.J. Singer, ed., Proceedings of the fourth triennial conference on research in the National Parks and equivalent reserves. Colorado State University, Fort Collins. Colorado.

Vosburgh, T. C., and L. R. Irby. 1998. Effects of recreational shooting on prairie dog colonies. Journal Wildlife Manage. 62(1):363-372.

Webb, R. H., and H. G. Wilshire, editors. 1983. Environmental effects of off-road vehicles: Impacts and management in arid regions. Springer-Verlag, New York, New York. 534pp.

CHAPTER 5

SEMI-AQUATIC MAMMALS

EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE
A Review for Montana

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MONTANA CHAPTER OF THE WILDLIFE SOCIETY

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ABSTRACT

Semi-aquatic mammals (beaver, muskrat, river otter, and mink) inhabit waterways and associated wetland and riparian habitats throughout Montana. Because these species require aquatic and adjacent shoreline habitats, they may be impacted by both water-based and shoreline recreational activities. The impacts of motorized boating are of particular concern. The number of boats registered in Montana increased 34% from 1990 to 1998. Personal watercraft registration increased 700% from 560 to 4,470 in the same period. Impacts of recreation on semi-aquatic mammals include disturbance effects to the animals themselves and habitat effects related to water quality, bank integrity, and vegetation. Disturbance may cause stressful physiological reactions, interrupt activities, and displace semi-aquatic mammals from preferred habitats, with resultant energetic consequences. Displacement can vary from a short-term flight and return or long-term abandonment of the area. Disturbance during spring and early summer (breeding, dispersal, parturition, and post-natal periods) may be most detrimental to productivity, although disturbance at any time of the year may lower fitness, reproductive success, and survival. Cover availability and the type, frequency, predictability, location, and duration of the activity may all influence semi-aquatic mammal responses to recreational disturbance. Semi-aquatic mammals concentrate their activities along the shore. The closer the recreational activity is to the shoreline, the greater the disturbance potential. Semi-aquatic mammals may habituate to non-threatening recreational activities if they occur in predictable areas at predictable times. The type, frequency, duration, and location of the activities also May influence recreation effects on semi-aquatic mammal habitats. Substantiated impacts of motorized recreation on aquatic and shoreline habitats include shoreline erosion, pollution from boat engines, contaminant resuspension and increased turbidity, increased turbulence, and laceration of aquatic vegetation by propellers. Bank stability and shoreline vegetation are important habitat components for semi-aquatic mammals. Motorized watercrafts generate wakes that may hit the shoreline and cause bank and substrate erosion, which impacts shoreline vegetation. Loss of shoreline vegetation makes the bank even more susceptible to continued erosion by natural and boat-induced waves. Wakes may also swamp den sites, erode den entrances, erode muskrat canals, swamp river otter latrine sites, and compromise the structural integrity of bank dens, beaver lodges, beaver caches, muskrat houses, and muskrat feeding platforms. Reduced boat speeds and increased operating distances from shore can lower bank erosion rates. Motorized boats, personal watercraft, and snowmobiles operating on frozen surfaces introduce oil residue and various derivatives from the combustion process into the water. These pollutants may directly impact fish, thereby affecting the forage base of mink and river otters, and bioaccumulate in the food chain. Uptake of petroleum hydrocarbons by aquatic animals has been documented. Motor boat activity also increases sediment resuspension and turbidity, which may decrease water clarity and increase nutrient loading. The removal of riparian habitat to develop public recreational facilities, private docks, and homesites in conjunction with the proliferation of artificial bank stabilization measures pose serious threats to semi-aquatic mammals and their habitats. The cumulative effects of habitat loss and recreational activities (including trapping) on semi-aquatic mammal populations need to be considered to determine the overall impacts of recreation. Responsible management of boating and shoreline recreation is essential to the conservation of semi-aquatic mammals in Montana.

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INTRODUCTION

Beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), river otter (*Lutra canadensis*), and mink (*Mustela vison*) are semi-aquatic mammals that inhabit a variety of waterways and associated wetland and riparian habitats throughout Montana. These species require both aquatic and adjacent shoreline habitats and may be impacted by recreational activities that occur in or along rivers, streams, lakes, ponds, marshes, and reservoirs. In general, any recreational activity conducted in or along a body of water has the potential to disturb semi-aquatic mammals and may also cause habitat degradation. Boating and shoreline recreational activities may displace denning, breeding, resting, foraging, or dispersing semi-aquatic mammals. In addition, water-based recreational activities can seriously impact marsh and riparian vegetation, bank stability, and water quality, which are essential habitat components for each of these species. The use of off-road vehicles (ORV) or snowmobiles along riparian banks, through wetlands, and on ice may also impact resident semi-aquatic mammals. The impacts of motorized boating are of particular concern due to the tremendous increase of boating activities on Montana waters. The total number of registered boat licenses in Montana increased from 36,744 to 49,119 (33.7%) between 1990 and 1998 (Youmans 1999). Of this total, personal watercraft (PWC, e.g., Jet Ski, Skidoo) numbers have shown the most dramatic rise, increasing from 560 to 4,470 (700%) in 8 years. The "2020 Vision for Montana State Parks" (Montana Fish, Wildlife & Parks 1998) lists water-based recreation and management as an issue and states, "One of the major sub-components of this issue [water-based recreation and management] is conflict between motorized and non-motorized recreational use of water. In particular, the management of personal watercraft has --as elsewhere in the country-- emerged as a contentious issue." However, conflict between water-based recreation and natural resource conservation is not considered an issue, nor even mentioned, in this important planning document.

An overview of semi-aquatic mammal ecology by species is presented to identify those times when disturbance may be most detrimental and to emphasize the dependence of these animals on certain bank, vegetative, and stream characteristics that are vulnerable to damage from motorized boating and other types of recreational activities. Beavers are discussed in more detail because abandonment or removal of beavers from an area may negatively affect other semi-aquatic mammals. The effects of recreation on semi-aquatic mammals are discussed in terms of disturbance effects to the animals themselves, habitat effects, and trapping.

BEAVER

Beavers are dependent on the riparian zone for both forage and shelter. Woody shoreline vegetation provides essential seasonal forage and building materials for dams, lodges, and caches. Beavers commonly occur in streams with sufficient flow for damming as well as rivers, lakes, ponds, and wetlands bordered by riparian shrub growth. On streams, beavers commonly build dams to control water levels and occupy a dome-shaped stick and mud lodge in the resulting pond. The main dam serves to impound water for the primary pond, which surrounds the lodge and contains the food cache. Secondary dams may be built to extend swimming areas and improve transportation of food and building supplies (Grasse and Putnam 1955). If dams are washed out or removed, beavers will rebuild, starting with the primary dam (Buech 1985). Beavers may occupy reservoirs, but suitable habitat is often limited by wind and wave erosion. Extensive water level fluctuations may reduce the area suitable for riparian shrub growth and may flood lodges and dens. Bays and inlets sheltered from strong winds may be the only suitable areas for any sustained use by beavers in large lakes and reservoirs (Slough and Sadleir 1977, Allen 1982).

Bank dens or lodges may be used to escape from predators and as resting areas, thermal cover, and protection for young (Allen 1982). Along rivers and reservoirs in central Montana, beavers preferred to build lodges or bank dens on sites with soil banks and soil underwater substrates (Bown 1988). Sites with rocky banks or substrates were seldom used. Lodges were seldom found on sites with less than 500 m of continuous riparian shrubs and trees adjacent to the lodge. Underwater den entrances are essential, and deep water near shore is an important habitat parameter. For sites to be habitable, water depth near shore should be sufficient to ensure a passable underwater entrance at low water. In areas where the water near shore was too shallow for beavers to construct and maintain an underwater entrance by burrowing through the soil, beavers piled sticks from the bank several feet into the water making a protected tunnel leading to a secure exit below the water line (Bown 1988). Extensive water level fluctuations reduce the suitability of sites for beavers. Low water depths can expose lodge or den entrances, leaving beavers vulnerable to predators (Easter-Pilcher 1987) and often leading to den abandonment (Bissell and Bown 1987). A minimum amount of water fluctuation is required for winter colony sites; severe high water from spring run-offs may flood lodges and dens, forcing adults with young kits to vacate.

Beaver cutting activity is seasonal, with the peak occurring during the fall, corresponding with the construction of food caches. Intensive, additional cutting activity becomes necessary in the summer if lodges have collapsed (Bown 1988). Beavers in northwestern Montana select woody stems according to their species, stem diameter, and distance from shore (Easter-Pilcher 1987). In general, preferred forage for beavers, in order of selection, includes aspen (*Populus* spp.), willow (*Salix* spp.), cottonwood (*Populus* spp.), alder (*Alnus* spp.), red osier dogwood (*Cornus* spp.), and maple (*Acer* spp.) (Hill 1982, Olson and Hubert 1994). In general, beavers in northwestern Montana prefer small (<2.5 cm) diameter stems that are found close to the shore; beavers also tend to cut larger stems (>2.5 cm in diameter) further inland, up to a size threshold which negates efficient transport back to the water (Easter-Pilcher 1987). Tree distribution in an area influences the distance from shore that beavers must travel to find forage. Beavers are vulnerable to predators when out of the water, and the availability of small-stem willow and/or cottonwood and their relative distance from the waterway are important factors to consider when assessing habitat quality and vulnerability to disturbance.

An active beaver colony is distinguished by the presence of a winter food cache. Availability of woody plants for a cache may limit the capacity of an area to support a colony through the winter (Boyce 1981, Allen 1982, Easter-Pilcher 1987). The availability of stream and vegetation characteristics necessary for winter colony sites may have the greatest potential influence on the survival and reproductive success of individual beaver colonies (Easter-Pilcher 1987). In northwestern Montana, preferred winter colony sites were located on wide, deep streams with mild gradients, a small amount of vertical water fluctuation, and small substrate where willow was the dominant vegetation (Easter-Pilcher 1987). Extensive use of islands and braided river segments for caching was noted by Martin (1977) on the Bighorn and Yellowstone rivers. On the Missouri River, caches were found significantly more often on islands than on main riverbanks with steep uplands (Bown 1988).

Bank erosion is extremely detrimental to beavers. Erosion can reduce the availability of riparian forage immediately adjacent to the shore and cause beavers to travel farther inland, increasing their exposure to humans, dogs, and other predators. Erosion also creates banks with relatively steep uplands characterized by relatively fast and deep water near shore, which makes it difficult for beavers to anchor a cache and creates unstable banks unsuitable for denning (Bown 1988). Bown (1988) states that “deep water and soil banks are of little use if they are unstable. Collapsing banks provide little shelter and may kill animals.” In essence, any change that destabilizes banks, reduces preferred woody vegetation, or compromises the security of den sites will reduce the suitability of an area for beavers.

Beavers are social animals and form colonies of related individuals. A typical beaver colony is a mated pair, young-of-the-year, and yearlings born the previous year (Bown 1988). The colony is typically organized around the adult female. She leads the colony in construction and maintenance of the dam(s) and lodge(s) and the gathering of food for winter caches. She is also the alpha member of the colony in dominance encounters (Olson and Hubert 1994). Adult beavers will be the first of a colony to emerge in the evening, checking to make sure the area is safe for their young kits and subadults (A. Easter-Pilcher, Professor of Biology, Western Montana College, Dillon, personal communication). When alarmed, beavers slap their tails primarily as a warning signal to family members to move from land or shallow water to deep water (Hodgdon 1978).

Beavers produce one litter per year and are apparently monogamous for life. The breeding period is primarily during February and March in northern and montane regions (Novak 1987). In general, reproduction appears to be density dependent, with an inverse relationship between colony size and litter size. Kits are usually born in May and June (Grasse and Putnam 1955). By mid- to late summer (July and August) when kits are about two months of age and weaned, they begin to leave the lodge on foraging trips.

By fall, kits are actively involved in building the cache and may travel almost as far from the lodge as adults (Buech 1985). Beavers are nocturnal and crepuscular (Hill 1982) and actively forage on the banks during these times.

Dispersal is as important to a species' survival as reproduction and longevity (Caughley 1977). Dispersal of 2 year-olds takes place shortly before the adult female gives birth to kits in the spring. Dispersers generally leave the natal colony in late winter or early spring and live as a "floating" population of transients (Van Deelen 1991). Dispersing beavers are prone to high mortality due to lack of shelter, starvation, and predation (Boyce 1974, Lidicker 1975). A study of beaver dispersal in northwestern Montana showed that beavers moved significantly greater distances more frequently during the period from April to June and lesser distances more frequently during July to November (Jackson 1990). Loss of stream-side vegetation may prevent successful beaver dispersal (Jackson 1990).

Beaver reproductive success is related to forage quality and availability (Easter-Pilcher 1987). Beavers self-regulate colony densities through intraspecific territorialism relative to the available food supply. Territories serve to regulate intraspecific strife as well as dispersal of young into unoccupied habitat (Payne 1984). Beavers will defend the colonial home range; dispersing beavers move through occupied waterways but are prevented from remaining by resident beavers (Van Deelen 1991). Beavers mark the perimeter of their colony territory with scent mounds consisting of mud and vegetation wetted with urine and castoreum from castor glands (Olson and Hubert 1994). Transient beavers appear to voluntarily avoid areas harboring scent mounds during dispersal. However, intraspecific strife can be an important cause of beaver mortality (Payne 1984). Activities that remove scent mounds may increase territorial disputes.

Recreational activities that induce or accelerate bank erosion and that manipulate water levels, may impact beavers through changes in woody shoreline vegetation and den site integrity. Sensitive seasons for beavers are the fall which corresponds with the peak of cutting and storing of woody riparian vegetation used as a winter food supply, the late winter to early spring period when sub-dominant individuals disperse, and from May to August which includes parturition and weaning of dependent young. On a daily basis, beavers are sensitive to disturbance at night and during early morning and evening twilight hours while actively foraging on the banks.

MUSKRAT

Muskrats depend on both aquatic and shoreline environments for food and shelter and are common inhabitants of rivers, streams, lakes, ponds, backwater sloughs, ditches, and other wetlands. This herbivorous species eats a variety of submergent, emergent, herbaceous, and woody plants, depending on season and availability. Cattail and bulrush are important muskrat foods (Willner et al. 1975); other typical foods are sedges, submergent plants, and bark of willows and red osier dogwood. Green algae constituted the most important group of plants consumed in freshwater areas in Maryland (Willner et al. 1975). Muskrats generally dig and live in bank dens if suitable high, firm banks are available. Muskrats also build houses in marsh habitats with abundant emergent vegetation by cutting and piling the vegetation into mounds in shallow water; houses are up to 2.5 m in diameter and vary in height from 0.4 to 1.3 m (Perry 1982). The house provides a dry nest and stable temperatures. During periods of low water, muskrats frequently construct canals that may be 30 cm or more deep that lead from the den site to open water. Muskrats like to leave the water to eat and construct feeding huts or platforms. They also construct "push-ups" when the marsh is frozen by cutting a hole through the ice and pushing up a 30-46 cm pile of roots or other vegetation; this forms an enclosed cavity on top of the ice that serves as a resting and feeding site (Perry 1982). Muskrats stay close to their primary den site; most foraging occurs within a 5 to 10 m radius of a lodge or pushup, and muskrat movement seldom exceeded 150 m (MacArthur 1978). Slough-dwelling muskrats in Canada used burrows in summer and constructed houses in the fall and push-ups in winter (Fuller 1951). Dens and houses as well as floating logs and other debris provide important resting habitat for muskrats. Kiviat (1978) reported use of muskrat lodges or dens by 60 different vertebrate species.

Muskrats generally reach their highest densities where favorable emergent vegetation and water are equally interspersed (Boutin and Birkenholz 1987). Water levels may be more important than the type of marsh vegetation in determining muskrat population levels (Bellrose and Brown 1941). Changing water levels were considered the principal factor limiting muskrat populations in marshes in North Carolina (Wilson 1949 as cited in Perry 1982). Water depths must be great enough to prevent solid freezing in winter, otherwise muskrats abandon the area (Boutin and Birkenholz 1987). Rivers or habitats with fluctuating water levels support relatively fewer muskrats per unit area in comparison to stable marshes (Bissell and Bown 1987). Muskrats are usually absent from portions of large lakes and reservoirs where wave action is severe (Errington 1963). Muskrats exhibit cyclic population fluctuations corresponding to population density and food abundance. When food is abundant, muskrats become overpopulated and generally consume all the available vegetation, including the soil-binding root systems, and ruin the feeding area for several years (Perry 1982).

Muskrats are primarily nocturnal although some travel and forage during the day, especially in spring and autumn. Muskrats are relatively short-lived species with high reproductive and mortality rates (Bissell and Bown 1987). Muskrats sexually mature in the spring following their birth. An individual will rarely survive 2 winters. The breeding season is related to the primary production season for vegetation, and varies from year-round in the southern United States to late June through mid-August in the Yukon Territory (Boutin and Birkenholz 1987). Where ice cover is present during winter, breeding is initiated when the wetlands are ice-free (Boutin and Birkenholz 1987). In Idaho, young were born between May and late August (Reeves and Williams 1956). Litter sizes range from 4 to 7 (Boyce 1977), with 2 or 3 litters per year (Boutin and Birkenholz 1987). Nest chambers are located above the water level, with one or more underwater entrance tunnels. The female covers the newborn young with shredded, dry vegetation when she leaves the nest (Perry 1982). Dispersal is most common during spring and autumn. Spring dispersal is associated with the aggressive establishment and defense of spring breeding territories (Boutin and Birkenholz 1987). Individuals that do not secure breeding territories are forced to disperse and are susceptible to a variety of mortality factors. Autumn dispersal is associated with extensive house building by young-of-the-year.

Recreational activities that reduce marsh vegetation, cause bank erosion, and jeopardize the integrity of constructed houses, tunnels, and feeding areas and the dryness of nests may negatively affect muskrats. Sensitive times for muskrats are during breeding in the spring, parturition in the spring and summer, dispersal in the spring and fall, and construction of houses in the fall.

RIVER OTTER

The northern river otter historically ranged across much of North American and adapted to a wide variety of aquatic habitats. A combination of human encroachment, habitat destruction, and over-harvest has eliminated otters from many previously occupied areas (Toweill and Tabor 1982). Since 1977, the river otter has been included in Appendix II of the Convention on International Trade in Endangered Species as a species likely to become threatened unless trade is regulated (U.S. Fish and Wildlife Service 1977). As a result, river otters must be managed to insure that stable or increasing populations exist, and states are required to provide the U.S. Endangered Species Office of Scientific Authority with information that justifies current river otter management practices.

River otters are dependent on both the aquatic and riparian environments for food and shelter. Riparian habitat is the key component of otter habitat (Melquist and Dronkert 1987). River otters have shown preferential use of densely vegetated banks, including banks with overhanging streamside vegetation and understory vegetative cover. River otters are also associated with areas of emergent vegetation in marshes (Melquist and Hornocker 1983, Polechla and Sealander 1985) and stable undercut banks that provide important seasonal cover (Waller 1992). During winter, ice can be an important source of cover especially in waterways where water levels have retreated and extensive mudflats separate the water from the banks (Waller 1992).

The availability of dens and resting sites is an important aspect of river otter ecology (Larsen 1983, Melquist and Hornocker 1983, Anderson and Woolf 1984). For these elusive animals, sheltered sites that provide security and seclusion are preferred (Melquist and Hornocker 1983). River otters do not excavate their own dens (Toweill and Tabor 1982), and the importance of beaver bank dens and lodges to otters for den and resting sites has been well-documented (Zackheim 1982, Melquist and Hornocker 1983, Polechla and Sealander 1985, Bradley 1986, McDonald 1989, Dronkert-Egnew 1991, Waller 1992). Other typical den sites include logjams and natural bank cavities sheltered by overhanging riparian vegetation, ice shelves, tree roots, log ramps, or boulders. Bank configuration and stability is thus an important habitat component for river otters, as it is for beavers, mink, and muskrats. The riparian habitat is also important to river otter selection of latrine sites. Scent marking with feces, urine, and anal sac secretions at specific latrine sites, which are often used year after year, is probably the most important method of intergroup communication (Melquist and Hornocker 1983). River otters prefer open, grassy areas between dense vegetation and other prominent places, such as channel confluences, for scent marking and eating fish (Zackheim 1982, Bissell and Bown 1987).

River otters are primarily piscivorous but also eat crayfish, amphibians, insects, small mammals, and birds (Toweill and Tabor 1982). They are opportunistic and tend to prey on fish that are easiest to capture. In general, abundant slow-swimming fish such as suckers (*Catostomus* spp.), squawfish (*Ptychocheilus oregonensis*), bullheads (*Ictalurus* spp.), and carp (*Cyprinus* spp.) are selected more often than fast-swimming salmonids. Exceptions occur when circumstances such as spawning make faster, more maneuverable fish vulnerable. Otters tend to forage along the shore, seeking potential prey in various hiding places and probing the substrate for insects. River otters are susceptible to biomagnification of persistent toxins such as industrial pollutants, heavy metals, and chlorinated hydrocarbons (Melquist and Dronkert 1987).

Natal den requirements are not well documented, but female otters appear to select secluded sites removed from the main shore (Reid 1982, Melquist and Hornocker 1983, Woolington 1984, Dronkert-Egnew 1991). Off-river den sites secure from fluctuating water levels that could flood the dens during spring run-off may be critical for river otter reproduction (Bissell and Bown 1987). Parturition peaks in March and April (Toweill and Tabor 1982). Breeding also takes place in the spring following parturition. By the time the pups are 3 months old (early summer), the family group (typically the adult female, 2-3 pups, and 1-3 subadults) moves to an area with abundant fish or other prey where the pups grow and develop survival skills (Melquist and Dronkert 1987). Mudflats, marshes, and backwater sloughs were important to family groups during the summer in Idaho (Melquist and Hornocker 1983). Little is known about river otter dispersal, but subadults may begin to disassociate from the family group about 3 months after the pups are born.

River otters have few natural predators but are most vulnerable on land. Dogs (*Canis familiaris*) are potential predators that may pose a serious threat to otter populations in developing (Melquist and Hornocker 1983) or heavily used recreational areas. Recreational activities that degrade riparian forests and marshes, erode the banks, or reduce beaver and fish populations are detrimental to river otters. Sensitive times for river otter are during parturition and breeding in the spring, and rearing of young in the summer.

MINK

Mink utilize a great variety of habitats and inhabit wetland areas of all kinds – banks of rivers, streams, lakes, ditches, swamps, marshes, and backwater areas. Allen (1982) suggested that permanence of water as well as shoreline and emergent vegetation were the most important variables for evaluating habitat suitability for mink in marshes and riverine habitats. The density of riparian shrubs and trees is also positively correlated to mink presence (Mason and MacDonald 1983). Areas far from water may be used when adequate food is lacking in the more aquatic areas. Unlike the otter, the mink is adapted to hunting terrestrial prey as well as aquatic prey and will feed on any animal it can find and kill. The opportunistic feeding behavior of the mink results in a varied diet; common food items include muskrats, mice and other small mammals, fish, birds, amphibians, crustaceans, insects, and reptiles. Mink forage extensively in and around logjams, large woody debris, rocky areas, driftwood, hollow logs, and unused beaver and muskrat dens and lodges. They also work the banks under shelf ice that is left above the water level in areas where water levels drop. The presence of vegetative bank cover and den sites are important habitat components.

The most widely used den sites are abandoned bank burrows of other animals, particularly muskrats (Eagle and Whitman 1987). Mink may also den in muskrat houses, cavities in roots of trees, rock or brush piles, logjams, and beaver lodges.

Mink are generally solitary and nocturnal, although females with litters may be active during the day. The breeding season occurs from late February to early April (Linscombe et al. 1982), and parturition occurs between April and June in most areas (Eagle and Whitman 1987). Average litter size is 4 but may vary from 1 to 8 (Linscombe et al. 1982). Mink reproductive success may be highly variable from year to year; reasons for this are not well understood and warrant further investigation (Eagle and Whitman 1987). Male mink are highly territorial and actively patrol and maintain their territories. Intraspecific aggression may result in more mink deaths than any other predator except humans (Eagle and Whitman 1987). Mink may adjust territories and become concentrated in response to abundant food availability such as during a spawning kokanee salmon *(Oncorhynchus nerka*) run (Melquist et al. 1981). Timing of dispersal is variable and may begin as early as July for larger males or as late as September for smaller juveniles; small females may not disperse until the following spring (Gerell 1970). Birks and Linn (1982) suggested that dispersal is a time of social instability in mink populations, causing increased patrolling of territories to maintain boundaries.

Mink are susceptible to biomagnification of stable environmental pollutants. Residues from mercury and halogenated hydrocarbon compounds (PCBs, DDT, DDE, dieldrin) are known biohazards for mink (Aulerich et al. 1974, O'Shea et al. 1981).

Recreational activities that reduce bank cover, decrease bank stability, impact mink's prey base, and introduce contaminants in the water are detrimental to mink. Sensitive times for the mink include spring breeding and parturition and summer dispersal.

EFFECTS OF RECREATION ON SEMI-AQUATIC MAMMALS

Disturbance Effects

Knight and Cole's (1995) statement "that recreational activities disturb wildlife is well appreciated but poorly understood" is particularly true regarding semi-aquatic mammals. An extensive literature search revealed no published studies that investigated the behavioral responses of semi-aquatic mammals to either recreational disturbance or general human disturbance. However, the elusive nature of most semi-aquatic mammals and the importance of secure den sites indicate an overall low tolerance to human presence. Bown (1988) indicated that extensive recreational use and shoreline development concentrated in low-relief areas may be one reason for the lack of beaver colonies on Hauser Lake and the presence of only 2 colonies on Holter Lake in Montana. In contrast, 3 reservoirs that had little to no human access or shoreline development showed colony densities within the variation shown on the Missouri River (up to 0.17 colonies per kilometer of shoreline). Melquist and Hornocker (1983) indicated that otters in Idaho seemed to prefer areas with minimum human activity and exhibited a nocturnal activity pattern in summer but not in winter, possibly in response to increased human disturbance during summer daylight hours. Disturbance of semi-aquatic mammals in response to human proximity, similar to that documented for other wildlife species, should be considered as an important effect of recreation until information is gathered that shows otherwise.

Physiological Responses - Disturbance by recreationists may cause stressful physiological responses in semi-aquatic mammals. Gabrielsen and Smith (1995) reviewed physiological responses of wildlife to disturbance and explained the "active defense response," better known as the flight or fight response, and the "passive defense response" such as hiding or playing dead. When river otters, mink, muskrats, and beavers encounter recreationists and flee in response, they are exhibiting the active defense response. Increased heart rate and blood flow are associated with this response. Semi-aquatic mammals that remain hidden in the den and do not flee may be exhibiting the passive defense response, which is also associated with physiological changes including decreased heart rate. Recreational activities that take place while semi-aquatic mammals are in their dens may be mistakenly interpreted as having little effect. However, Smith and Woodruff's (1980) study of woodchucks (*Marmota monax*) showed the stress that denning animals might experience from the presence of humans or dogs. Woodchucks retreated to their burrow when disturbed by a human or dog and showed the active defense response, including increased heart rate. Once inside the burrow, they immediately responded with the passive defense response including reduced respiration and heart rate. The amount the heart slowed was stimulus dependent. When a dog or human approached the burrow and began digging, the heart rate would slow down even further. Similar results were exhibited by eastern chipmunks (*Tamias striatus*), fox squirrels (*Sciurus niger*), grey squirrels (*Sciurus* spp.), and rabbits (*Sylvilagus* spp.); these species would first retreat to cover (the active defense response with increased heart rate) when approached by a human or a dog and then would engage in the passive defense response. When squirrels were disturbed, they would hide, and their heart rate would often drop by 60%. If the human or dog approached too closely, the squirrels would flee, and their heart rate increased from less than 200 beats/minute (bpm) to more than 450 bpm. Although similar physiological studies have not been conducted on semi-aquatic mammals, Gabrielsen and Smith's (1995) review of the literature "suggests that the passive defense response is present in all animals: invertebrates, fish, amphibians, reptiles, birds, and mammals when subjected to strong fear, pain, anger, shock, or situations with few possibilities of escape."

In general, an animal's reaction when it senses an approaching human or predator depends, in part, on its age, the availability of cover, and the distance to the threat. Animals exhibited the passive defense response when threatened if the animals had cover or a safe hiding place (Gabrielsen and Smith 1995). Approaching recreationists may disproportionately affect young-of-the-year and dispersers that lack knowledge of immediate escape. Furthermore, a fast approach on motorboats, PWCs, snowmobiles, or ORVs would give animals less time for retreat than slower activities.

In addition, wild animals that appear to be unaffected by human intrusion and remain in proximity to humans may, in fact, be experiencing stress that is not visually evident. For example, nesting marine birds in the Galapagos Islands appeared "tame" but experienced high stress from human presence as evidenced by increased heart rate from 2 to 4 times the normal rate when approached at a distance of 58 feet (Jungius and Hirsch 1979). Thus, it is prudent to assume that semi-aquatic mammals experience stressful physiological responses, whether in the den site or out, when approached by people boating, camping, walking, swimming, or riding bikes, snowmobiles, PWCs, or ORVs. Research on the physiological responses of semi-aquatic mammals to human and dog intrusions is needed to fully understand the tolerance and consequences of such disturbances.

Displacement - In addition to causing stressful physiological responses, human intrusion can cause displacement, prevent access to resources, and thus reduce reproduction and survival. The displacement of semi-aquatic mammals because of boating or other recreational activities may have either short-term effects or long-term effects. Josselyn et al. (1989) described short-term effects as those where "species are acclimated to disturbance and return after a brief retreat" and long-term effects as those that are "cumulative so that, over time, species use the area less and less." Both short-term and long-term displacement have negative repercussions, such as inhibiting access to food for less tolerant individuals or contributing to crowding in some areas, which may lead to increased aggression and lower fitness (Knight and Cole 1995). Short-term effects may be the active retreat of the beaver, muskrat, mink, or otter to a nearby den site or available cover, which, in effect, interrupts foraging, resting, or traveling activities with resultant energetic consequences. Long-term effects would, of course, be abandonment of the area. Where habitat is limited, semi-aquatic mammals that abandon an area because of recreational activities may have to travel long distances in search of alternative sources of food and cover. Increased chances of predation, starvation, or intraspecific strife may occur as a result.

Although disturbance has resultant energetic consequences throughout the year, the reproductive period is often considered the time when disturbance would have the most serious consequences. According to Gabrielsen and Smith's (1995) review, "Studies of the effect of human disturbance on wildlife have revealed that the immediate postnatal period in mammals is a critical period. During this time, human disturbance should be prevented or reduced to a minimum. Both the behavioral and physiological responses to disturbance during this time, whether active or passive defense, are profound and are important to the individual's fitness." Disturbance at breeding time can also have serious direct effects on reproductive success (Josselyn et al. 1989). Spring and early summer is then a critical time when disturbance of semi-aquatic mammals should be prevented as much as possible.

Furthermore, repeated displacement during feeding and resting periods causes increased energy expenditures through avoidance behaviors, which also may result in a population reduction (Bartelt 1987). As a result of displacement to areas of lower habitat quality, beaver reproductive fitness and colony size may be effectively lowered (Easter-Pilcher 1987). Dispersing beavers in suboptimal habitat moved significantly greater distances more frequently than beavers dispersing from primary habitat (Jackson 1990). Similar increases in energy expenditure would be expected in river otter, mink, and muskrat when displaced into lower quality habitats.

Boating activity may also cause disturbance and possible abandonment of an area by fish and/or consequent reduced hatching success. This may impact the prey base for river otters and mink. Todd (1987) concluded that of the different types of human activities, canoeing during the spawning season probably had the most effect on small-mouth bass (*Micropterus dolomieui*) behavior. Nest disturbance by boaters was less in deeper water than in shallow water. Boats traveling at slow speeds near nests usually drove male nest-guarding long-ear sunfish (*Lepomis megalotis*) from their nests, increasing the likelihood of egg predation (Mueller 1980).

Overall, if animals are denied access to areas that are essential for reproduction and survival, the population will decline. Likewise, if animals are disturbed while performing essential behaviors, such as foraging or breeding, the population will also likely decline (Knight and Cole 1995). Therefore, it is essential that both short-term and long-term effects of recreational disturbance throughout the year be evaluated for each species of semi-aquatic mammal.

Obviously, not all types of recreational activities will be equally disturbing to semi-aquatic mammals. For instance, there are many types of watercraft, both motorized and non-motorized, and not all are equally disruptive. Non-motorized boats as well as PWCs, jet boats, and airboats can penetrate shallow water areas that are inaccessible to outboard motorboats and, thus, may cause greater disturbance. Tuite et al. (1983) generalized that “motorboats have the greatest disturbance potential because they involve both movement and noise, whereas sailing and canoeing are less disruptive as they involve only movement.” However, the engine noise from motorized watercraft may alert animals to the pending approach of recreationists, whereas silent canoeists or kayakers may startle unsuspecting animals.

The frequency and persistence of the activity and whether or not it occurs in isolation or in conjunction with other recreational activities will also influence the response. For example, the simultaneous occurrence of hikers on shore and boaters in the water may be much more stressful and disturbing than if just one or the other was occurring. The frequency of the recreational activity will, in large part, determine if the response is short-term or long-term desertion of the area.

The predictability of the recreational activity, if non-threatening, will determine if semi-aquatic mammals become habituated and show little overt response. Directing shoreline activities to designated areas will enable semi-aquatic mammals to predict locations of human activity and avoid encounters. Unrestrained dogs are not predictable and will increase the radius of unexpected human activity considerably. Semi-aquatic mammals may habituate to motorized and non-motorized watercraft if the watercraft use is restricted to predictable areas or distances from shore. Secure den sites and escape cover are essential habitat components regardless of habituation.

Hunting Activities - Hunting is an important disturbance on a seasonal basis. Fall hunting activities in riparian areas occur when beavers are most often on the banks cutting stems for caches and muskrats are actively building houses. Mink and river otters may benefit from wounded or abandoned upland game birds or waterfowl during hunting season. However, dogs that accompany bird hunters present a danger to semi-aquatic mammals.

Harassment and Vandalism - Unfortunately, human nature is such that increased recreational use in and along a waterway will likely increase the number if incidents when semi-aquatic mammals are deliberately harassed or killed, and beaver houses, muskrat lodges, and other important denning areas are destroyed. Easter-Pilcher (Professor of Biology, Western Montana College, Dillon, personal communication) suggests that beavers may be the most impacted semi-aquatic mammal because of their obvious presence on waterways or lakes. Dams, stick lodges, and even some bank dens are relatively obvious to the general public. People can easily access and invade the security habitat of beavers – climbing on lodges, banging paddles on the lodges as they float by, snorkeling around the lodge, and chasing the animal while on motorized watercraft. Beaver lodges may also attract youths who throw fireworks and firecrackers. Muskrat houses and push-ups are also obvious and may invite many of the same actions described for beavers. In addition, boaters may destroy beaver dams deliberately or unintentionally when boating over an inlet to gain access to a beaver pond.

Direct Mortality - Deliberate or accidental mortality can also result from impacts with vehicles, snowmobiles, and boats. Dead beavers with gashes from propeller strikes were observed on 3 separate occasions in a beaver pond in the Swan River National Wildlife Refuge in northwestern Montana (M. Madel, Montana Department of Fish, Wildlife & Parks, Choteau, personal communication). Several studies have documented road kills as a mortality factor in river otter populations (Melquist and Hornocker 1983, Anderson and Woolf 1984, Foy 1984, A. Waller, Wildlife Biologist, Kalispell, personal observation).

Effects on Habitat

The literature indicates that many of the effects of shoreline and water-based recreation relate to water quality, bank erosion, and impacts to vegetation. Motorized boats and PWCs are associated with many habitat degradation problems likely to affect semi-aquatic mammals. Boating is listed as one of the recreational activities that defeats the original purpose of the U.S. Fish and Wildlife Service National Refuge System (Conservation Committee Report 1978). In addition to auditory disturbance of animals, substantiated impacts of motorized boating include shoreline erosion, pollution from boat engines, sediment resuspension and turbidity, increased turbulence, and laceration of aquatic vegetation by propellers. The effects of motorized boating and other recreational activities on semi-aquatic mammal habitat are presented in terms of water quality, banks and vegetation, and fishing and fisheries management.

Effects on Water Quality - Seabrooke and Marsh (1981) state that "the ability of our water bodies to accommodate water-oriented recreation is limited. Once this limit is exceeded, pollutants from various recreational activities may cause a deterioration of the environment." Water quality determines the abundance and diversity of insects, amphibians, reptiles, crustaceans, fish, and aquatic and shoreline vegetation an area will support and thus can have a major impact on semi-aquatic mammals. All types of shoreline and aquatic recreational activities have the potential of introducing garbage, excrement, and other pollutants into the water, depending on the practices of those recreating. Dietrich and Mulamoottil (1974) examined the bacteriological quality of reservoir water and correlated those results with the intensity of recreational use. They suggest that swimming and other recreational activities in the water impair water quality. Swimming, cleaning fish, boat launching, and motor boating were hypothesized as probable causes of higher observed concentrations of coliform bacteria, phosphates, and nitrogen in the Boundary Waters Canoe Area in northeastern Minnesota (King and Mace 1974). King and Mace (1974) also showed that campsite use caused highly significant increases in coliform bacteria populations likely caused by drainage from pit toilets located at each campsite. A serious impact of waterfront recreational homes is the use of the adjacent water bodies for sewage disposal (Seabrooke and Marsh 1981). The concentration of pollutants in the water depends in large part on the size of the water body and the amount of inflow and outflow.

The littoral zone, the shallow water area where aquatic vegetation grows, provides important foraging sites for river otters, mink, and muskrats. The littoral zone is particularly vulnerable to environmental deterioration; boat and propeller movements, exhaust, and oil and gas leaks from outboard motors can disrupt plant systems and destroy fish spawning grounds (Jaakson 1979).

Motorized boats, particularly those using two-cycle outboard motors, have the potential to greatly impair waters inhabited by semi-aquatic mammals. National Park Service (NPS 1999) reviewed water quality concerns related to PWC usage and concluded that the use of PWCs has resulted in measurable water quality degradation in the nation's lakes and reservoirs. Almost all PWCs utilize two-stroke engines (NPS 1999), which introduce pollutants into the water during operation. Compounds emitted from two-cycle outboard motors originate from unburned fuel that is discharged into the receiving water and the combustion process that discharges additional toxic compounds into the water. Estimates of the amount of unburned fuel discharged into the water vary. Wall and Wright (1977) estimate as much as 10% of gasoline from outboard motors may be discharged into the water. National Park Service (1999) states that a conventional two-stroke outboard PWC will expel as much as 30% of the incoming fuel mixture, unburned, via the exhaust (California Environmental Protection Agency, Air Resources Board 1999). Jackivicz and Kuzminiski (1973) claim that more than half the original fuel mixture for outboard motors may be emitted, unburned, into receiving waters.

Contaminants introduced into the water from outboard motors include oil residue and various derivatives from the fuel and the combustion process. Specific compounds discharged into the water during outboard motor operation include: benzene, toluene, ethyl benzene, xylene (collectively called BTEX); methyl tertiary butyl ether (MTBE); and polycyclic aromatic hydrocarbons (PAHs) (National Park Service 1999). The BTEX compounds readily transfer from the water to air, whereas MTBE and PAHs do not. The following information about MTBE, an oxygenate added to gasoline, and PAH contaminants is summarized from NPS (1999). The recreational use of two-stroke engines has been identified as a primary cause of MTBE contamination of lakes and reservoirs. For example, Donner Lake in California contained 45-65 pounds of MTBE prior to peak boating activity; 2 months after increased boating activity MTBE had increased to 250 pounds (NPS 1999). In a newly constructed lake, MTBE levels ranged from 50-60 micrograms per liter after a three-day PWC event. This level is 10-12 times the level the state of California adopted as its standard for secondary drinking water (based on taste and odor) and 3.8-4.6 times the MTBE level California adopted as its public health goal (does not pose any significant risk to health). Little is known about the ecological risks to aquatic organisms from MTBE, although one study indicated that adverse effects on rainbow trout were not expected until concentrations of MTBE in the water column reached 4600-4700 micrograms per liter (Johnson 1998). This study identified research needs that included investigation into the ecological risk to benthic invertebrate communities from MTBE. At least 5 water management districts in California have banned or restricted the use of motorboats on reservoirs because of water contamination concerns.

The combustion process of a two-stroke engine creates several PAH compounds that have been detected in the water, at least 3 of which are probably human carcinogens (NPS 1999). It is known that PAHs accumulate in the tissue of aquatic organisms, raising concerns about their effects on fish and their possible biomagnification in mink and river otters. One study found that levels of PAHs in two-stroke motorboat emissions had significant negative impacts on fish growth and zooplankton survival and reproduction in Lake Tahoe (Oris et al. 1998). Tjarnlund et al. (1996) found several different morphological anomalies in fathead minnows (*Pimephales promelas*) and elevated levels of DNA-adducts in the blood, liver, and kidneys of perch (*Perca flavescens*) exposed to two-stroke motor exhaust levels that would be found in or near the wake of such a boat. In rainbow trout (*Onchorhynchus mykiss*), DNA, enzyme activity, and carbohydrate metabolism functions were disrupted by exposure to exhaust components (Tjarnlund et al. 1995).

National Park Service (1999) concluded, "the use of two-stroke engines, including PWCs, has resulted in the contamination of lakes and reservoirs. MTBE and PAHs are commonly observed two-stroke contaminants and pose the most serious threats to human and ecological health…. Aquatic ecological communities do not appear to be threatened by observed concentrations of MTBE; however, more research is needed to reinforce this conclusion. PAH concentrations in lakes and reservoirs with high motorboat activity have been found at levels dangerous to aquatic organisms. The concentrations causing adverse effects can be extremely low due to PAH phototoxicity, especially in oligotrophic waters where sunlight penetration is high. Some are concerned about possible adverse effects from PAHs bound to sediment, especially in waters higher is suspended solids; this phenomenon is currently poorly understood…. Management strategies adopted by other agencies include outright bans on PWC and restricted use of two-stroke motors." The impact of PAHs, MTBE, and other contaminants from motorboats and PWC on semi-aquatic mammals needs to be investigated.

Factors affecting the quantity of compounds exhausted from two-stroke outboard motors include horsepower rating, crankcase size, composition of fuel mixture, tuning of the engine, and speed of operation (Jackivicz and Kuzminiski 1973). Direct-injection two-stroke or four-stroke engines are not nearly as polluting as the conventional two-stroke engine (NPS 1999). Direct-injection two-stroke engines (the first model debuted in 1998) reduce smog-forming pollution in a typical 90-horsepower engine by four-fold when compared to a conventional two-stroke engine. Four-stroke engines (used in automobiles) with the same horsepower reduce smog-forming pollution another four-fold as compared to direct-injection two-stroke engines.

Similar pollution problems have been documented for two-cycle snowmobile engines. Snowmobile activity on frozen ponds, especially in powder-snow conditions, has been shown to introduce toxic chemicals into the water. Studies by Adams (1974) showed that lead and hydrocarbons from snowmobile exhaust could reach levels that are potentially harmful to fish at ice-out in small ponds. Brook trout (*Salvelinus fontinalis*) showed significant uptake of lead and hydrocarbons attributed to snowmobile exhaust.

In addition, pollutants from outboard motors may have direct effects on fish and, thus, indirectly affect mink and river otters. Early studies showed that concentrations of petroleum wastes in water as low as 1 part per million (ppm) killed sunfish (*Lepomis gibbosus*) (Shelford 1917 as cited in Adams 1974) and that 5 to 50 ppm of petroleum hydrocarbons killed most fish (McKee and Wolf 1963 as cited in Adams 1974). A review of the effects of outboard motor subsurface exhausts on water quality and aquatic biota identified undesirable tastes and odors and the appearance of oily substances in the water as potential problems (Jackivicz and Kuzminiski 1973). In sufficiently high concentrations, outboard motor exhaust water was found to exhibit a toxic effect to fathead minnows and bluegills (*Lepomis macrochirus*), and taint the flesh and affect the reproduction of various other fish. Wall and Wright (1977) found that fish flesh became tainted at a fuel-usage level of 32 liters of outboard motor fuel per 4 million liters of lake water per season. Carp (*Cyprinus carpio*) and trout were found to be sensitive indicators for the degree of water pollution from dissolved engine gases because accumulation of combustion products can be tested very quickly in terms of fish flesh flavor (Ludemann and Pflaum 1968). Such contamination in fish may make them unpalatable to mink and river otters. The effect of oily residue in the water from outboard motor exhausts and accidental fuel spills on the insulating ability of underfur in beavers, muskrats, mink, and river otters may also be a localized concern.

Bioaccumulation of contaminants is another concern. Uptake of petroleum hydrocarbons by aquatic animals has been documented. Blumer et al. (1970) found that hydrocarbons concentrated in the fatty tissue of bivalves and were passed from prey to predator along the food chain. Biomagnification of petroleum hydrocarbons may be occurring in semi-aquatic mammals, especially in river otters and mink. Many studies have documented biomagnification of other toxins in river otters and mink. O'Conner and Nielsen (1981) identified lethal methylmercury levels for river otters and pointed out that although the direct sources of these pollutants may have been controlled, "Sediments heavily laden with inorganic mercury will continue to contribute to methylmercury levels in fresh water biota for many years to come." In addition to the ongoing emissions of exhaust compounds into the water, turbulence and disturbance of sediments by motorized boating can redistribute toxic compounds that have settled into the substrate.

Another potential problem with recreational boating is their role as weed distributors. Weed distribution was significantly associated with boating and angling (Johnstone et al. 1985). Boat inspections at 14 lakes in New Zealand revealed that 5.4% of the boats entering the lakes carried vegetative fragments of aquatic weeds and that 27% had come from other lakes. Another concern is the potential transport of disease vectors from one waterway to another.

Motorboat activity also resuspends sediment and increases turbidity, which may decrease water clarity, increase nutrient loading, and stimulate the growth of algae in lakes. This, in turn, may affect the entire food chain, including semi-aquatic mammals. Nedohin and Elefsiniotis (1997) determined that motorboat activity created enough disturbance on the bottom sediments to release the stored phosphorous into the overlying water and accelerate eutrophication. In a related study, recreational motorboats with engines of

28-165 hp were operated on 3 lakes in Florida; the resultant agitation of the water column increased water turbidities, phosphorus concentrations, and chlorophyll-a concentrations (Yousef et al. 1980). Garrad and Hey (1987) demonstrated the resuspension of bed sediments by a single moving boat and concluded that boat speed and frequency have important implications for management of turbidity levels. Garrad and Hey (1988) also found that daily patterns of boat traffic were responsible for large diurnal variations in suspended sediment concentration and that much of the boat-induced sediment remained in suspension until the next day. Macrophytes declined from increased shading due to the increased levels of turbidity. Fish diversity and abundance also declined with diminishing food resources. Similarly, Hardman and Cooper (1980) associated increased boat traffic with reduced macrophytic vegetation, and Moss (1977) found highly significant correlations between phytoplankton numbers and turbidity in the Norfolk Broads in England. Smart et al. (1985) investigated the effects of commercial and recreational traffic on the resuspension of sediment in a main channel and a backwater channel of Navigation Pool No. 9 of the upper Mississippi River. In the main channel, 50% of the recreational vessel passages caused increases in total non-filterable residue (TNFR), and all passages increased average particle size of suspended silts. In the backwater channel, all recreational passages caused increases in TNFR and average particle size. Bed-sediment composition, location of the vessels in the channel, channel geometry, the number of successive passages, and vessel speed were identified as factors affecting the magnitude of sediment resuspension. Depending on the type of natural plankton, induced suspended sediments in the upper Great Lakes either inhibited or enhanced primary productivity (Munwar et al. 1991). The authors concluded that it is important to evaluate the implications of plankton enhancement because it may increase eutrophication and the propagation of nuisance blooms and change intricate food web interactions. Luttenton and Rada (1986) compared disturbance regimes in the Mississippi River and found localized physical disturbance, induced by motorized boat traffic and wind-generated wave action, inhibited development of algal communities. Their results demonstrated that turbulence strongly influenced the structure of complex attached algal communities that are a food resource for microcrustaceans, insect larvae, and minnows. Such disturbances of the food chain may limit the resources available to higher trophic levels and ultimately reduce the food resources of muskrats, mink, and river otters.

Effects on Banks and Vegetation - Bank stability is an important habitat component for beavers, muskrats, mink, and river otters. Erosion of natural riverbanks by boat-generated waves is well documented and becoming an increasingly serious problem. Motorized boats generate wakes that can hit the shoreline and cause bank and substrate erosion, which in turn results in loss of stabilizing shoreline vegetation. Loss of shoreline vegetation makes the bank even more susceptible to continued erosion by natural and boat-induced waves. Natural or artificial water level fluctuations will also have an increased erosional effect on these compromised banks, causing further loss of streamside cover and increased sedimentation. In Alaska, Dorava and Moore (1997) determined that bank loss in a non-motorized segment of the Kenai River was approximately 75% less than that observed in the river reach with the highest boat use and 33% less than that observed in the river reach with the lowest boat-use. Peak boat activity coincided closely with peaks in measured bank erosion. Boat wakes contributed about 80% of the total energy dissipated against the banks of the Kenai River study sites during the peak flow and peak boat activity period. In the Norfolk Broads in England, river widths have increased dramatically, mainly due to waves from boat traffic and a decline in bank vegetation (Garrad and Hey 1988).

Bank material, in large part, determines the susceptibility of the bank to erosion. Soil banks are preferred by beavers for den sites (Bown 1988) and are much more susceptible to wave erosion than are rocky banks. The frequency, height, and force of the wave against the bank also affect the degree of erosion. The length, speed, and draft of the boat, as well as the distance from shore and number of times waves are generated (the number of passages along a certain shoreline) determine the height, strength, and number of waves the shoreline must absorb. Bhowmik (1975) documented that as the distance between the moving boat and the shore declines, the exposed shore must dissipate a major portion of the wave energy in a very short time period. In other words, as the distance from shore becomes greater, the impact to the shoreline is less. Das (1969) documented an increase in peak wave energy with increased boat speed. Thus, wakes created by high-speed boating near the shoreline will produce powerful, erosive wakes against the bank, while boating at lower speeds near the center of the water body will be much less damaging. High-speed boating will have less impact in the center of large bodies of water such as reservoirs and large lakes. In rivers, small lakes and ponds, high-speed watercraft can create powerful, eroding wakes even when traveling near the center of the waterway. Erosion and loss of critical marsh habitat at the Kendall-Frost Mission Bay Reserve wetland near San Diego is attributed to PWCs and the wake from motorboats (Dayton and Levin 1996). Nanson et al. (1994) found that maximum wave heights above 35 cm eroded all but the most resistant bank sediments. Wakes from motorized watercraft can seriously impact the stability of semi-aquatic mammal bank dens by increasing bank erosion. Boat wakes may also swamp den sites, erode the entrances to dens, erode muskrat canals, and compromise the structural integrity of beaver lodges, beaver caches, and muskrat houses and feeding platforms. Muskrat houses are especially susceptible to swamping from boat wakes. Neonate muskrats are blind and helpless, unable to swim for the first 2 weeks. The female covers the young with shredded dry vegetation when she leaves. Boat wakes may compromise the dryness of the muskrat nests as well as the natal dens of beavers, otters, and mink. Furthermore, river otter latrine sites and scent markings and mounds left by beavers, muskrats, and mink may also be washed away by boat wakes, which may lead to heightened intraspecific confrontations.

Speed and access limits can reduce the amount and rate of erosion caused by motorized boating. For example, the wash from high-speed tourist boats is causing erosion of the formerly stable banks of the lower Gordon River within the Tasmanian Wilderness World Heritage Area in Australia (Bhowmik 1975). Speed and access restrictions have considerably slowed, but not stopped, erosion on the now destabilized banks. With the introduction of a 9-knot speed limit, the mean rate of erosion of estuarine banks slowed from 210 to 19 mm/year. Erosion was reduced to 3 mm/year when commercial cruise-boat traffic was stopped. Bhowmik (1975) suggested making a 100-ft (30.5 m) strip close to shore off-limits to high-speed motorboats in order to minimize the damage to the shore by boat-generated waves. Garrad and Hey (1988) recommend reducing riverbank erosion by controlling boat wash by reducing boat speeds to 5 mph or less in most regions.

In addition to reducing boat speeds, Garrad and Hey (1988) recommend introducing protective vegetation to reduce riverbank erosion. Introduction of non-native vegetation to the riparian area could have serious impacts on the native vegetation and should be discouraged in favor of projects using native species. Erosion by boat wakes may increase the use of artificial bank-protection measures, such as riprap or retaining walls, which destroy natural bank habitat for beavers, river otters mink, and muskrats. For example, several different types of bank-protection measures were engineered to reduce or eliminate bank erosion on the Kenai River (Dorava and Moore 1997). These include coconut-spruce trees cabled to the bank, rock riprap piled against the bank, and vertical wooden retaining walls. Car bodies, tires, gravel, and concrete retaining walls are other typical bank stabilization materials. Although artificial bank stabilization may succeed in stopping localized erosion, it may also make the bank impenetrable and remove important denning habitat for river otters, mink, beavers, and muskrats. Concrete retaining walls are especially undesirable due to their permanency.

The ongoing removal of riparian habitat because of increased residential and associated recreational development is a major threat to semi-aquatic mammals in Montana. A decrease in mink activity accompanied shoreline development by cottage owners in central Ontario (Racey and Euler 1983). The Corps of Engineers (COE) received 1756 Section 404 Permit applications to modify wetlands (including streambanks) in Montana between 1 January 1987 and 31 August 1993. COE approved 99.5% of these applications (Montana Audubon Council 1993). In northwestern Montana, the total number of stream bank alteration applications (the 310 permit program) submitted to the Flathead County Conservation District (FCCD) increased as follows: 35 between 1981-1985, 63 between 1986-1990, and 114 between 1991-1995. Applications received by FCCD to construct boat docks or ramps or to excavate canals or boat slips increased from 4 between 1981-1987 to 51 between 1988-1995 (Waller 1997). Temporary docks that do not destroy the configuration of the bank are not as damaging as large, permanent facilities. Furthermore, landowners may be intolerant of river otter scat on docks or the removal of ornamental trees by beavers and, consequently, trap them out of the surrounding area.

The construction of small dams on outlets to increase water depth and provide docking for boats can impact beaver lodge and bank den security by changing water levels above and below the dam (A. Easter-Pilcher, Professor of Biology, Western Montana College, Dillon, personal communication). Waters that are maintained at high levels to accommodate owners of marinas and docks also negatively affect semi-aquatic mammals. Beavers on rivers and reservoirs cannot control water levels with their dams as they do on streams and are at the mercy of natural or human-influenced fluctuations (Bown 1988). Moderate flooding on downstream floodplains at the appropriate time of year is prevented by human development on floodplains in most areas. In Montana, rivers typically show a natural discharge peak in May or June, followed by lows in late summer to winter, depending on rainfall. Below dams, discharge peaks are often artificially delayed and may remain high into or through the summer season (Bown 1988). The seeds of some riparian trees remain viable for a very short time and require newly exposed moist sites to germinate. Artificially maintaining high water through the germination period restricts opportunities for cottonwood reproduction (Bown 1988), thus impacting a major source of food for beavers.

Laceration of aquatic vegetation by propellers with subsequent loss of faunal habitat and substrate stability is another potential impact of motorized boating in semi-aquatic mammal habitat. Boufard (1982) studied canvasbacks and redheads and noted that "boat propeller action can remove all vegetation, cause a decline in plant species composition, and seriously reduce submergent vegetation. The loss of aquatic vegetation, compounded by wakes from larger boats, caused bank erosion and siltation in some areas. This was especially prevalent in ponds where people water-skied." Muskrats use vegetation immediately surrounding their dwelling for construction purposes, and the cutting of submergent vegetation by propellers may reduce the availability of suitable housing sites.

Off-road vehicles traveling along riparian areas, running up and down the banks, or through temporarily dry wetlands will impact the bank and shoreline configuration, vegetation, and soils. Snowmobiling may also be detrimental. Snowmobiling in a cattail marsh caused a 23% decrease in cattail density, 12% decrease in cattail height, and a 44% increase in sedge (*Carex* spp.) density (Sojda 1978). Confining snowmobiling to dispersed trails was recommended to prevent serious alteration of wildlife habitat in cattail marshes. Snowmobile and ORV activity may also cause unstable banks to collapse and compromise the stability of bank dens.

Non-motorized recreational activities may also impact shoreline habitats used by semi-aquatic mammals. People recreating along the shore may trample bank and emergent vegetation, reducing the amount of cover available to semi-aquatic mammals and facilitating erosion in these trampled areas. Plants in wet soils are especially vulnerable to trampling (Willard and Marr 1970). In a marsh, soil compaction results in lower surface elevations and changes the inundation regime to which plants are exposed (McIntyre 1977). In addition, the aerial portions of plants in wet soil tend to be more succulent and, therefore, more breakable than plants in drier soils (Willard and Marr 1970). Continued trampling or vehicle traffic will halt vegetation re-establishment. People walking up and down the banks along runs used by semi-aquatic mammals can remove important trailside security cover, decrease the stability of the bank, and destroy important river otter latrine sites and territorial scent markings left by beavers, mink, and muskrats. Walking along the edge of the bank can also cause unstable bank dens and undercut banks to cave in.

Fishing and Fisheries Management - Fisheries management practices can have serious consequences for river otters and mink by changing the composition and abundance of available prey species. Management practices that remove nongame fish in favor of trout and salmon will decrease the availability of catchable prey for river otters and mink. The use of chemicals such as rotenone to kill resident fish populations prior to re-stocking game fish will remove the current fish prey base for river otters and mink. River otters have drowned in gill nets (Mowbray et al. 1979, Anderson and Woolf 1984); mink, beavers, and muskrats could also potentially get tangled in gill nets. Entanglement in fishing line is also a threat to all semi-aquatic mammals. Accidental ingestion of fishing line may also occur. Swans have died from lead poisoning by ingesting lead fishing weights (Hardman and Cooper 1980). This same localized threat may be present for foraging mink, river otters, and muskrats in certain areas. River otters have been accused of seriously depredating game fish and consequently may be trapped out of certain areas, although food habits studies have all indicated that otters prey primarily on nongame fish species (Toweill and Tabor 1982). Removal of nuisance river otters and mink that are attracted to fish hatcheries may be a source of high local mortality.

Removal of beavers and destruction of their dams are fisheries management practices that have obvious, direct effects on beavers and the beaver-created habitat used by mink, river otters, and muskrats. Beavers can improve fish habitat by increasing the standing crop of invertebrates available to foraging fish, and several studies have documented increased production of trout and other game fish in beaver-influenced streams (Rutherford 1955, Gard 1961, Knudsen 1962 as cited in Van Deelen 1991). However, beavers have been associated with reduced trout production by reducing streamside shade and diminishing water velocity causing higher water temperatures and the smothering of spawning redds (Patterson 1950, Knudsen 1962 as cited in Van Deelen 1991). Benefits to game fish from the removal of beavers and beaver dams will be at the expense of semi-aquatic mammals (and amphibians, reptiles, waterfowl, and shorebirds) inhabiting the impounded area.

Trapping

Beaver, muskrat, mink, and river otter are managed as furbearers in Montana. Regional harvest records are used to evaluate population trends and status. Harvest records may provide some indication of abundance, but fluctuations in harvest rate often reflect changes in fur prices rather than population size (Melquist and Hornocker 1983). Consequently, information on trapping effort per unit area is necessary to correctly interpret population trends from harvest data.

Statewide Montana trapping season dates have been and currently are November 1 – April 15. Special closures to beaver and river otter trapping occur in certain drainages. There is no limit per trapper on the number of beaver, mink, or muskrat that can be taken. Trappers are limited to one river otter each season.

Beaver - Because of the high degree of specialization beavers have for shoreline habitat and their inability to survive elsewhere, beavers are vulnerable to exploitation (Hill 1982). With careful consideration of available habitat, population status, environmental factors, and need for damage control, overexploitation of beaver can be avoided. Timing of trapping seasons to avoid the breeding season can minimize potential population impacts of removing members of alpha pairs (Hill 1982). Developed recreation facilities such as roads, trails, picnic areas and campgrounds in close proximity to beaver ponds may produce indirect impacts to beaver . New or improved roads and trails may provide increased access to beaver habitat by fur trappers.

Beavers will readily investigate foreign castoreum deposits in their territory, a response that has been utilized by trappers (Hill 1982). Beaver pelts are graded (and priced) according to size. Therefore, trappers prefer to take the largest animals from a colony. If one or both of the alpha adults are trapped, breeding may be precluded for that breeding season (Hill 1982). Fur trapping is highly influenced by economics, and the value of beaver pelts is subject to widely fluctuating world demand, probably more so than for any other furbearer (Payne 1984). Because of their association with beaver ponds, other furbearers are impacted by beaver trapping. Beaver trappers commonly catch otter, mink and raccoon *(Procyon lotor)* in water and bank sets and bobcat (*Lynx rufus)* and fox *(Vulpes* spp.) in land sets located near beaver ponds (Hill 1982). In Ontario, after many years of trial and error and scientific research, annual harvest quotas for sustained yield have been set at 30% of the beaver population, regardless of the habitat type (Novak 1987). Closure of certain drainages during periods of high pelt prices may be necessary to protect core populations where habitat is fragmented.

Muskrat - Muskrats have higher reproductive rates and can sustain greater harvest rates than the other semi-aquatic mammals. A review of reported muskrat harvest rates indicated that the percent of muskrats that can be harvested without jeopardizing the population varies from 50% to 80% (Perry 1982). Boutin and Birkenholz (1987) state that the accuracy of reported harvest rates for muskrats, which generally vary between 50% and 90% of the autumn population, are suspect due to difficulties in estimating muskrat populations prior to the harvest. Parker and Maxell (1984) investigated the responses of muskrat populations to trapping seasons and found that muskrat populations harvested at a 60% rate during both spring and autumn declined, whereas populations harvested at this rate in either autumn or spring did not decline. Trapping of muskrats should take into account the fact that muskrats exhibit population cycles that correspond to population density and food abundance.

Montana Fish, Wildlife & Parks (FWP) surveys all trappers by mail to estimate harvest rates. During the last 15 years, pelt prices for all furbearing animals have been considerably less than in the late 1970s and early 1980s. The number of muskrats reported in the annual survey has declined during the last decade or so, possibly in response to low pelt prices. In the winter of 1987-88, trappers harvested an estimated 41,578 muskrats statewide in comparison to only 11,727 muskrats trapped in 1994-95 (the last year of published reports).

Mink - Mink harvest fluctuates greatly from year to year and may not be correlated to pelt price (Linscombe et al. 1982). Therefore, harvest records may indicate trends in mink numbers. Pelt prices and mink harvest numbers should be compared using Montana data to determine if any correlation exists. Eagle and Whitman (1987) state, "All Canadian provinces and territories and 47 American states allow at least limited harvest of mink; however, only 2 provinces and 11 states conduct population inventories (Deems and Pursley 1983)." Montana is among the states that do not conduct annual mink population inventories. Mink are generally considered abundant throughout their range, and populations appear to withstand or rebound quickly from harvest pressure (Eagle and Whitman 1987). An imposed quota on registered traplines maintains a more stable annual mink production; without a quota, over-trapping may cause lowered production (Linscombe et al. 1987). Eagle and Whitman (1987) recommend population monitoring to establish a more scientific basis for management decisions.

River Otter - Most river otters are trapped accidentally in beaver sets, and the 1 river otter/trapper limit in Montana was initiated in 1956 for this reason (Zackheim 1982). River otter harvest is positively correlated with beaver harvest and greatly influenced by river otter and beaver pelt prices. River otters are susceptible to overharvest because they travel extensively within a rather restricted waterway, using traditional latrine sites, and even one trapper can impact the entire population if trapping in an important travel corridor. Toweill and Tabor (1982) state that "the impact of even a single knowledgeable trapper at some point along a given watercourse may severely affect local populations." Conservative trapping policies are essential to assure that healthy and viable river otter populations are maintained. Identification of important travel corridors and traditional latrine sites would enable trapping restrictions in these areas. Information on river otter trapping effort is necessary to interpret population trends from harvest data. Drainage-specific harvest locations have been collected since the 1977-78 trapping season, but trapping effort data is still needed (Waller 1997). Closure of important drainages may be necessary during periods of high beaver or river otter pelt prices. Trapper education programs that include river otter-sign identification would enable trappers to avoid areas with obvious river otter use while trapping beaver.

CONCLUSIONS

Water-based and shoreline recreational activities have the potential to disturb and displace semi-aquatic mammals and impact the aquatic and shoreline habitats on which they rely. Factors that can influence the responses of semi-aquatic mammals to recreational disturbance include the availability of cover, the type of recreational activity, and the frequency, duration, predictability, and location of that activity. Disturbance may cause stressful physiological reactions, interrupt activities, and displace semi-aquatic mammals from preferred habitats, with resultant energetic consequences. Displacement can vary from a short-term flight to long-term abandonment of an area. Disturbance during spring and early summer, when breeding, dispersal, parturition, and the post-natal period take place, may be most detrimental to productivity, although disturbance at any time of the year may lower fitness, reproductive success, and survival. Beaver, mink, muskrat, and river otter concentrate their activities along the shore, and the closer any recreational activity is to the shoreline the greater the disturbance potential. Semi-aquatic mammals may habituate to non-threatening recreational activities if they occur in predictable areas at predictable times. The effect of recreation on semi-aquatic mammal habitat is also influenced by the type of recreational activity, and the frequency, duration, and location of that activity. Of particular concern are the impacts from motorized boats and PWCs on marsh and riparian vegetation, bank stability, and water quality. The impacts of boat wakes on bank dens, beaver caches and lodges, muskrat houses and feeding platforms, and river otter latrine sites are also concerns. Substantiated impacts from motorized boating that are potentially harmful to semi-aquatic mammals include bank erosion, loss of vegetation, sediment resuspension and turbidity, introduction of contaminants into the water, and fish toxicity. Reduced boat speeds and increased operating distances from shore can lower the rate of bank erosion and amount of sediment resuspension caused by motorized watercraft. Regarding water pollution, the density of boats and the size and hydrology of the water body will largely determine the concentration of contaminants and the effect on semi-aquatic mammals. Furthermore, the removal of riparian habitat for the development of public recreational facilities, private docks and homesites, and bank stabilization measures is a serious threat to semi-aquatic mammals. All in all, there are many factors to consider when assessing the effects of recreation on semi-aquatic mammals. The cumulative effects of habitat loss and different recreational activities, including trapping, on beaver, muskrat, mink, and river otter populations need to be considered to determine the overall impacts of recreation on semi-aquatic mammals. Responsible management of boating and shoreline recreational activities is essential to the conservation of semi-aquatic mammals in Montana.

RECOMMENDATIONS

1. Establish limits on the speed and use of motorized watercraft according to the size, hydrology, and ecological characteristics of the water body to minimize bank erosion, loss of shoreline vegetation, sediment resuspension, and water pollution:
    - Require no-wake or reduced-speed operation within a buffer strip along the shoreline. Ideally, the buffer strip should be wide enough to allow wakes from boats outside the buffer strip to dissipate before reaching the shoreline.
    - Direct high-speed watercraft activities (e.g., water skiing, jet skiing) to large bodies of water, such as large lakes and reservoirs. High-speed activities should also be directed away from the shoreline and away from semi-aquatic mammal habitat that is usually limited in these large bodies of water.
    - Prohibit the use of motorized watercraft in bodies of water such as ponds and shallow backwaters susceptible to severe turbidity, accumulation of contaminants, and other impacts from even low-speed operation.
    - Inform motorized watercraft users about the impacts of boat wakes, the need for limiting high-speed operations and successive passes near shore, the amount of pollution associated with different types of engines, and ways to reduce the quantity of compounds exhausted such as tuning the engine. Provide this information with annual boat license decals.
2. Minimize disturbance to semi-aquatic mammals in shoreline habitats:
    - Establish temporary buffer zones along quality shoreline habitats during sensitive times, particularly in fragmented habitat.
    - Direct shoreline recreational activities to designated areas to enable semi-aquatic mammals to predict human activity at these locations and avoid encounters.
    - Locate trails, roads, picnic areas, campgrounds and other recreational facilities away from riparian and shoreline habitats. Restrict snowmobiles and ORVs from off-trail use, and nonmotorized activities as well if necessary, to protect nearby riparian and shoreline habitats.
    - Provide designated stopping areas for boaters periodically along the watercourse. These should be located in marginal habitat.
    - Require dogs to be under control at all times.
    - Inform recreationists about the possible impacts of disturbance on semi-aquatic mammals.
    - Establish minimum approach distances to beaver lodges and muskrat houses in heavily used recreation areas to prevent harassment and vandalism.

3. Monitor the concentrations of fuel and exhaust contaminants in waters and limit the number of watercraft, if necessary. The bacteriological quality of waters near recreational facilities should also be monitored and pit toilets located to prevent drainage of contaminants into the water system.

4. Monitor the bioaccumulation of toxic compounds associated with recreational activities (including contaminants that have accumulated in the sediment) in harvested river otter, mink, muskrat, beaver, and fish.

5. Monitor populations of semi-aquatic mammals so that recreational management decisions, including harvest regulations, are made on a scientific basis.

6. Trapping recommendations include:
   - Adjust the length of the trapping season and/or bag limits commensurate with pelt prices and population trends.
   - Increase the geographic specificity of trapping regulations to prevent localized overharvest.
   - Avoid trapping beaver during the breeding season (February-March according to Novak 1987) to minimize the potential impacts of removing members of alpha pairs (Hill 1982).
   - Establish local non-trapping areas at important latrine sites and travel corridors used by river otters.
   - Require trapper education programs that provide information on the biology and ecology of semi-aquatic mammals and techniques for avoiding nontarget species.

7. The decision to remove beaver and beaver dams to benefit game fish populations should be made jointly by fisheries and wildlife managers.

8. Monitor shoreline development and reduce streambank alterations and riparian habitat removal:
   - Develop government regulations that establish riparian buffer zones, define construction setback limits, prevent artificially raising construction sites above the floodplain, and restrict non-essential alteration of banks.
   - Educate waterfront landowners about the importance of maintaining the natural bank vegetation.
   - Pursue shoreline conservation easements.

There is currently a tax on motorboat fuel that makes up 18.8% of the Montana FWP Parks Division Operations budget. An additional 3.8% of the Parks Division Operations budget comes from decal boat registration fees (Montana Fish, Wildlife, and Parks 1998). Therefore, there appears to be a source of funding to address natural resource impacts from these recreational activities. We recommend that monies collected from motorboat fuel and decal boat registration fees be considered as a source of funding for the above recommendations and following information needs.

INFORMATION NEEDS

1. Investigate the species-specific effects of various types of recreational disturbance on semi-aquatic mammals in Montana habitats.

2. Determine acceptable levels of exposure of semi-aquatic mammals to MTBE, PAHs, and other contaminants from recreational activities. Also, determine water quality preferences of beaver, muskrat, river otter, and mink.

3. Improve techniques to make semi-aquatic mammal trapping more species-specific.

4. Investigate the variability of mink reproductive success from year to year and the influence of pelt price on mink harvest.

LITERATURE CITED

Adams, E. S. 1974. Uptake by brook trout of lead and hydrocarbons from snowmobile exhaust: I. Field study. II. Lead and hydrocarbon content of snow after snowmobiling. III. Laboratory study. IV. Stamina tests. Dissertation, University of New Hampshire.

Allen, A. W. 1982. Habitat suitability index models: beaver. U.S. Department of Interior, Fish and Wildlife Service. FWS/OBS-82/10.30. 20pp.

Anderson, E. A., and A. Woolf. 1984. River otter (*Lutra canadensis*) habitat utilization in northwestern Illinois. Final Report. Illinois Department Conservation, Springfield, Illinois. 90pp.

Aulerich, R. J., R. K. Ringer, and S. Iwamoto. 1974. Effects of dietary mercury on mink. Archives of Environmental Contamination and Toxicology 2:43-51.

Bartelt, G. A. 1987. Effects of disturbance and hunting on the behavior of Canada Goose family groups in east central Wisconsin. Journal of Wildlife Management 51(3):517-522.

Bellrose, F. C., and L. G. Brown. 1941. The effect of fluctuating water levels on the muskrat population of the Illinois River Valley. Journal of Wildlife Management 5:206-212.

Bhowmik, N. G. 1975. Boat-generated waves in lakes. Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers 101:1465-1468.

Birks, J. D. S., and I. J. Linn. 1982. Studies of home range of the feral mink, *Mustela vison.* Symp. Zoological Society London 49:231-257.

Bissell, G. N., and R. Bown. 1987. Effects of water level fluctuations on aquatic furbearer distribution, abundance, and habitat in the northern Flathead Valley. Final Report. Montana Department of Fish, Wildlife and Parks, Kalispell, Montana.

Blumer, M., G. Souza, and J. Sass. 1970. Hydrocarbon pollution of edible shellfish by an oil spill. Marine Biology 5(3):195-202.

Boufard, S. H. 1982. Wildlife values versus human recreation: Ruby Lake National Wildlife Refuge. Transactions of the North American Wildlife and Natural Resources Conference 47:553-558.

Boutin, S., and Birkenholz, D. E. 1987. Muskrat and round-tailed muskrat. Pages 314-325 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario.

Bown, R. 1988. Beaver habitat along rivers and reservoirs in central Montana. Thesis, University of Montana, Missoula, Montana.

Boyce, M. S. 1974. Beaver population ecology in Alaska. Thesis, University of Alaska, Fairbanks, Alaska. 161pp.

Boyce, M. S. 1977. Life histories in variable environments: applications to geographic variation in the muskrat (*Ondatra zibethicus*). Dissertation. Yale University, New Haven, Connecticut. 146pp.

Boyce, M. S. 1981. Habitat ecology of an unexploited population of beavers in interior Alaska. Pages 155-186 *in* J. A. Chapman and D. Pursley, editors. Worldwide Furbearer Conference Proceedings. Volume 1.

Bradley, P. V. 1986. Ecology of river otters in Nevada. Thesis. University of Nevada, Reno, Nevada. 99pp.

Buech, R. R. 1985. Beaver in water impoundments: understanding a problem of water-level management. Pages 95-105 *in:* D.M. Knighton, compiler. Water Impoundments for Wildlife: A Habitat Management Workshop. General Technical Report NC-100. U.S. Forest Service, St. Paul, Minnesota.

California Environmental Protection Agency, Air Resources Board. 1999. Fact Sheet -- New Regulations for Gasoline Engines. http://www.arb.ca.gov/msprog/marine/marine.htm.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley & Sons. New York, New York. 234pp.

Conservation Committee Report. 1978. Management of National Wildlife Refuges in the United States: its impacts on birds. Wilson Bulletin 90:309-321.

Das, M. M. 1969. Relative effect of waves generated by large ships and small boats in restricted waterways. Report No. HEL-12-9. Army DACW72-68-C-0034. Hydraulic Engineering Lab, University of California, Berkeley, California. 41pp.

Dayton, P. K., and L. A. Levin. 1996. Erosion of cordgrass at Kendall-Frost Mission Bay Reserve. California Sea Grant. Biennial Report of Completed Projects 1992-94. California Sea Grant College Program, University of California, La Jolla, California. 179pp.

Deems, E. F., Jr., and D. Pursley. 1983. North American furbearers: a contemporary reference. International Association Fish and Wildlife Agencies, Maryland Department Natural Resources, Washington, D.C. 223pp.

Dietrich, P., and G. Mulamoottil. 1974. Does recreational use of reservoirs impair water quality? Water and Pollution Control 112:16-18.

Dorava, J. M., and G. W. Moore. 1997. Effects of boat-wakes on streambank erosion, Kenai River, Alaska. U. S. Geological Survey Water-Resources Investigations Report, U. S. Geological Survey, Anchorage, Alaska. 84pp.

Dronkert-Egnew, A. E. 1991. River otter population status and habitat use in northwestern Montana. Thesis, University of Montana, Missoula, Montana. 112pp.

Eagle, T. C., and J. S. Whitman. 1987. Mink. Pages 614-626 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario.

Easter-Pilcher, A. L. 1987. Forage utilization, habitat selection and population indices of beaver in northwestern Montana. Thesis. University of Montana, Missoula, Montana. 88pp.

Errington, P. L. 1963. Muskrat populations. Iowa State University Press, Ames, Iowa. 665pp.

Foy, M. K. 1984. Seasonal movement, home range, and habitat use of river otter in southeastern Texas. Thesis, Texas A & M University, College Station, Texas. 102pp.

Fuller, W. A. 1951. Natural history and economic importance of the muskrat in the Athabasca-Peace Delta, Wood Buffalo Park. Canadian Wildlife Service Wildlife Management Bulletin Series 1, Number 2. 98pp.

Gabrielsen, G. W., and E. N. Smith. 1995. Physiological responses of wildlife to disturbance. Pages 95-107 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington D.C.

Gard, R. 1961. Effects of beaver on trout in Sagehen Creek, California. Journal of Wildlife Management 25:221-242.

Garrad, P. N., and R. D. Hey. 1987. Boat traffic, sediment resuspension and turbidity in a Broadland river. Journal of Hydrology 95:289-297.

Garrad, P. N., and R. D. Hey. 1988. River management to reduce turbidity in navigable Broadland rivers. Journal of Environmental Management 27:273-288.

Gerell, R. 1970. Home ranges and movements of the mink (*Mustela vison* Schreber) in southern Sweden. Oikos 21:160-173.

Grasse, J. E., and E. F. Putnam. 1955. Beaver management and ecology in Wyoming. Federal Aid in Wildlife Restoration Project, Bulletin No. 6. Wyoming Game and Fish Commission, Cheyenne, Wyoming.

Hardman, J. A., and D. R. Cooper. 1980. Mute swans on the Warwickshire Avon – a study of decline. Wildfowl 31:29-36.

Hill, E. P. 1982. Beaver. Pages 256-328 *in* J.A. Chapman and G.A. Feldhamer, editors. Wild Mammals of North America: biology, management, and economics. The Johns Hopkins University Press, Baltimore, Maryland.

Hodgdon, H. E. 1978. Social dynamics and behavior within an unexploited beaver (*Castor canadensis*) population. Dissertation, University of Massachusetts, Massachusetts Cooperative Wildlife Research Unit. 322pp.

Jaakson, R. 1979. Shoreline recreation planning: a systems view. Pages 303-320 *in* G. Wall, editor. Recreational land use in southern Ontario. Department of Geography Publication Series No. 14, University of Waterloo, Ontario.

Jackivicz, T. P., and L. N. Kuzminiski. 1973. A review of out-board motor effects on the aquatic environment. Journal of Water Pollution Control Federation 45(8):1759-1770.

Jackson, M. D. 1990. Beaver dispersal in western Montana. Thesis. University of Montana, Missoula, Montana. 79pp.

Johnson, M. L., 1998. Ecological risk of MTBE in surface waters. John Muir Institute of the Environment, University of California, Davis, California. http://tsrtp.ucdavis.edu/mtberpt/homepage.html

Johnstone, I. M., B. T. Coffey, and C. Howard-Williams. 1985. The role of recreational boat traffic in interlake dispersal of macrophytes: a New Zealand case study. Journal of Environmental Management 21:263-279.

Josselyn, M., M. Martindale, and J. Duffield. 1989. Public access and wetlands: impacts of recreational use. Technical Report #9. Romberg Tiburon Centers, Center for Environmental Studies, San Francisco State University, Tiburon, California. 56pp.

Jungius, H., and U. Hirsch. 1979. Herzfrequenzanderungen bei Brutvogeln in Galapagos als Folge von Storungen durch Besucher. Journal fur Ornithologic 120:299-310. (German with English summary).

King, J. G., and A. C. Mace, Jr. 1974. The effects of recreation on water quality. Journal of Water Pollution Control Federation 46(11):2453-2459.

Kiviat, E. 1978. Vertebrate use of muskrat lodges and burrows. Estuaries 1(3):196-200.

Knight, R. L., and D. N. Cole. 1995. Wildlife responses to recreationists. Pages 51-69 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington D.C.

Knudsen, G. J. 1962. Relationship of beavers to forests, trout and wildlife in Wisconsin. Wisconsin Conservation Department Technical Bulletin 25. 25pp.

Larsen, D. N. 1983. Habitats, movements, and foods of river otters in coastal southeastern Alaska. Thesis. University of Alaska, Fairbanks, Alaska. 149pp.

Lidicker, W. Z., Jr. 1975. The role of dispersal in the demography of small mammals. Pages 103-128 *in* F. B. Golley, K. Petrusewicz, and L. Ryszkowski, editors. Small mammals: their productivity and population dynamics. Cambridge University Press, Cambridge.

Linscombe, G., N. Kinler, and R. J. Aulerich. 1982. Mink (*Mustela vison*). Pages 629-643 *in* J.A. Chapman and G.A. Feldhamer, editors. Wild Mammals of North America: biology, management, and economics. Johns Hopkins University Press, Baltimore, Maryland.

Ludemann, K. T., and W. Pflaum. 1968. Pollution of waters by motorized operations. Especially outboard motors. Water Pollution Abstracts 41: 85-86.

Luttenton, M. R., and R. G. Radda. 1986. Effects of disturbance on epiphytic community architecture. Journal of Phycology 22:320-326.

MacArthur, R. A. 1978. Winter movements and home range of the muskrat. Canadian Field-Naturalist 92:345-349.

Martin, P. R. 1977. The effects of altered streamflow on furbearing mammals of the Yellowstone River Basin, Montana. Yellowstone Impact Study Technical Report No. 6. Montana Department of Natural Resources and Conservation, Helena, Montana. 79pp.

Mason, C. F., and S. M. MacDonald. 1983. Some factors influencing the distribution of mink (*Mustela vison*). Journal of Applied Ecology 21:281-283.

McDonald, K. P. 1989. Survival, home range, movements, habitat use, and feeding habits of reintroduced river otters in Ohio. Thesis, Ohio State University, Columbus, Ohio. 129pp.

McIntyre, M. B. 1977. The biotic and physical effects of trampling on salt marsh (*Salicornia virginica* L.). Thesis, San Diego State University, San Diego, California. 97pp.

McKee, J. E., and H. W. Wolf. 1963. Water quality criteria. California State Water Quality Control Board, Sacramento, California. Publication No. 3-A.

Melquist, W. E., and M. G. Hornocker. 1983. Ecology of river otters in west central Idaho. Wildlife Monograph 83. 60pp.

Melquist, W. E., and A. E. Dronkert. 1987. River otter. Pages 626-641 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario.

Melquist, W. E., J. S. Whitman, and M. G. Hornocker. 1981. Resource partitioning and coexistence of sympatric mink and river otter populations. Pages 187-220 *in* J. A. Chapman and D. Pursley, editors. Proceedings Worldwide Furbearer Conference. Frostburg, Maryland.

Montana Audubon Council. 1993. Protecting Montana's wetlands: an overview of Montana's Section 404 Program. Montana Audubon Council, Helena, Montana. 30pp.

Montana Fish, Wildlife & Parks. 1998. 2020 Vision for Montana State Parks. System plan abridged version. Montana Fish, Wildlife & Parks, Helena, Montana. 196pp.

Moss, B. 1977. Conservation problems in the Norfolk Broads and rivers of East Anglia, England – phytoplankton, boats and the causes of turbidity. Biological Conservation 12:95-114.

Mowbray, E. E., D. Pursley, and J. A. Chapman. 1979. The status, population characteristics and harvest of the river otter in Maryland. Maryland Wildlife Administration, Publications in Wildlife Ecology 2, Annapolis, Maryland. 16pp.

Mueller, G. 1980. Effects of recreational river traffic on nest defense by longear sunfish. Transactions of the American Fisheries Society 109:248-251.

Munwar, M., W. P. Norwood, and L. H. McCarthy. 1991. A method for evaluating the impacts of navigationally induced suspended sediments from the Upper Great Lakes connecting channels on the primary productivity. Hydrobiologia 219:325-332.

Nanson, G. C., A. Von Krusenstierna, E. A. Bryant. 1994. Experimental measurements of river-bank erosion caused by boat-generated waves on the Gordon River, Tasmania. Regulated Rivers: Research & Management 9(1):1-14.

National Park Service. 1999. Water quality concerns related to personal watercraft usage. Draft internal literature review. Water Resources Division, National Park Service, Fort Collins, Colorado. 11pp.

Nedohin, D. N., and P. Elefsiniotis. 1997. The effects of motorboats on water quality in shallow lakes. Toxicological and Environmental 61(1-4):127-133.

Novak, M. N. 1987. Beaver. Pages 282-312 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario.

O'Conner, D. J., and S. W. Nielsen. 1981. Environmental survey of methylmercury levels in wild mink (*Mustela vison*) and otter (*Lutra canadensis*) from the northeastern United States and experimental pathology of methylmercurialism in the otter. Pages 1728-1745 *in* J. A. Chapman and D. Pursley, editors. Proceedings of the Worldwide Furbearer Conference, Frostburg, Maryland.

Olson, R. and W.A. Hubert. 1994. Beaver: Water resources and riparian habitat manager. University of Wyoming, Laramie, Wyoming. 48 pp.

Oris, J. T., A. C. Hatch, J. E. Weinstein, R. H. Findlay, P. J. McGinn, S. A. Diamond, R. Garrett, W. Jackson, G. A. Burton, and B. Allen. 1998. Toxicity of ambient levels of motorized watercraft emissions to fish and zooplankton in Lake Tahoe, California/Nevada, USA. Poster number 3E-P005, 8th Annual Meeting of the European Society of Environmental Toxicology and Chemistry (SETAC-Europe), 14-18 April 1998, University of Bordeaux, Bordeaux, France.

O'Shea, T. J., T. E. Kaiser, G. R. Askins, and J. A. Chapman. 1981. Polychlorinated biphenyls in a wild mink population. Pages 1746-1751 *in* J. A. Chapman and D. Pursley, editors. Proceedings of the Worldwide Furbearer Conference, Frostburg, Maryland.

Parker, G. R., and J. W. Maxwell. 1984. An evaluation of spring and autumn trapping seasons for muskrats, *Ondatra zibethicus*, in eastern Canada. Canadian Field-Naturalist 98:293-304.

Patterson, D. 1950. Beaver-trout relationships. Wisconsin Conservation Bulletin 15(3):9-11.

Payne, N. F. 1984. Population dynamics of beaver in North America. Acta Zoologica Fennica 172:263-266

Perry, H. R., Jr. 1982. Muskrats. Pages 282-325 *in* J. A. Chapman and G. A. Feldhamer, editors. Wild Mammals of North America: biology, management, and economics. The Johns Hopkins University Press, Baltimore, Maryland.

Polechla, P. J., Jr., and J. A. Sealander. 1985. An evaluation of the status of the river otter (*Lutra canadensis*) in Arkansas. Final Report. Arkansas Game and Fish Commission. Federal Aid Project No. W-56-23. 157pp.

Racey, G. D., and D. L. Euler. 1983. Changes in mink habitat and food selection as influenced by cottage development in central Ontario. Journal of Applied Ecology 20:387-402.

Reeves, H. M. and R. M. Williams. 1956. Reproduction, size, and mortality in the Rocky Mountain muskrat. Journal of Mammalogy 37:494-500.

Reid, D. 1982. River otter ecology in northeastern Alberta. Annual report. 1981-1982. Department of Biology, University of Calgary, Alberta. 38pp.

Rutherford, W. H. 1955. Wildlife and environmental relationships of beavers in Colorado Forests. Journal of Forestry 53:803-806

Seabrooke, A. K., and J. S. Marsh. 1981. The environmental impact of water-based recreation: an annotated bibliography. Public Administration Series: Bibliography P-777. Vance Bibliographies, Monticello, Illinois. 15pp.

Shelford, V. E. 1917. Experimental study of the effects of gas wastes upon fishes. Illinois State Lab Natural History Bulletin, Volume 11, Article No. 6.

Slough, B. G., and R. M. F. S. Sadleir. 1977. A land capability classification system for beaver (*Castor canadensis* Kuhl). Canadian Journal of Zoology 55(8):1324-1335.

Smart, M. M., R. G. Rada, D. N. Nielsen, and T. O. Claflin. 1985. The effect of commercial and recreational traffic on the resuspension of sediment in Navigation Pool 9 of the Upper Mississippi River. Hydrobiologia 126:263-274.

Smith, E. N., and R. A. Woodruff. 1980. Fear bradycardia in free-ranging woodchucks (*Marmota monax*). Journal of Mammalogy 61:750-753.

Sojda R., Jr. 1978. Effects of snowmobile activity on wintering pheasants and wetland vegetation in northern Iowa marshes. Thesis, Iowa State University, Ames, Iowa. 72pp.

Tjarnlund, U., G. Ericson, E. Lindesjoo, I. Petterson, and L. Balk. 1995. Investigation of the Biological Effects of 2-Cycle Outboard Engines' Exhaust on Fish. Marine Environmental Research 39:313-316.

Tjarnlund, U., G. Ericson, E. Lindesjoo, I. Petterson, G. Kerman, L. Balk. 1996. Further Studies of the Effects of Exhaust from Two-Stroke Outboard Motors on Fish. Marine Environmental Research 42:267-271 .

Todd, B. L. 1987. Movement patterns and habitat use of stream-swelling smallmouth bass. Thesis, University of Missouri, Columbia, Missouri. 105pp.

Toweill, D. E., and J. E. Tabor. 1982. River otter (*Lutra canadensis*). Pages 688-703 *in* Wild Mammals of North America: biology, management, and economics. J.A. Chapman and G.A. Feldhamer, editors. The Johns Hopkins University Press, Baltimore, Maryland.

Tuite, C. H., M. Owen, and D. Paynter. 1983. Interaction between wildfowl and recreation at Llangorse Lake and Talybont Reservoir, South Wales. Wildfowl 34:48-63.

U.S. Fish and Wildlife Service. 1977. International trade in endangered species of wild fauna and flora. Federal Register 42:10462-10488.

Van Deelen, T. R. 1991. Dispersal patterns of juvenile beavers in western Montana. Thesis, University of Montana, Missoula, Montana. 91pp.

Wall, G., and C. Wright. 1977. The environmental impact of outdoor recreation. University of Waterloo, Ontario. Department of Geography Publication Series 11. 69pp.

Waller, A. J. 1992. Habitat use of river otters in northwestern Montana. Thesis, University of Montana, Missoula, Montana. 75pp.

Waller, A. J. 1997. River otter use of latrine sites in the Flathead River Drainage, northwestern Montana – Summer 1997. Unpublished report. Montana Fish, Wildlife and Parks, Helena, Montana. 16pp.

Willard, B., and J. Marr. 1970. Effect of human activities on alpine tundra ecosystems in Rocky Mountain National Park, Colorado. Biological Conservation 2:257-265.

Willner, G. R., J. A. Chapman, and J. R. Goldsberry. 1975. A study and review of muskrat food habits with special reference to Maryland. Maryland Wildlife Administration, Publications in Wildlife Ecology 1. 25pp.

Wilson, K. A. 1949. Investigations on the effects of controlled water levels upon muskrat production. Proceedings Southeast Association Game and Fish Commissioners 3. 7pp.

Woolington, J. D. 1984. Habitat use and movements of river otters at Kelp Bay, Baranof Island, Alaska. Thesis, University of Alaska, Fairbanks, Alaska. 147pp.

Youmans, H. 1999. Project Overview. Pages 1.1-1.18 *in* G. Joslin and H. Youmans, coordinators. The effects of recreation on Rocky Mountain Wildlife: a review for Montana. Committee on Effects of Recreation on Wildlife. Montana Chapter of the Wildlife Society. 307pp.

Yousef, Y. A., W. M. McLellon, and H. H. Zebuth. 1980. Changes in phosphorus concentrations due to mixing by motorboats in shallow lakes. Water Research 14:841-852.

Zackheim, H. 1982. Ecology and population status of the river otter in southwestern Montana. Thesis, University of Montana, Missoula, Montana. 100pp.

CHAPTER 6

UNGULATES

EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE
A Review for Montana

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MONTANA CHAPTER OF THE WILDLIFE SOCIETY

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ABSTRACT

Ungulates provide a large percentage of the recreational opportunities for wildlife enthusiasts in the State of Montana. Hunting, wildlife viewing, and photography generate economic benefits in excess of $450 million annually. However, recreational activities have the potential not only to displace ungulates to private land where they may cause damage, but also to have negative direct and indirect effects to the populations themselves. During winter, many ungulates are seasonally confined to restricted geographic areas with limited forage resources. In these conditions, physiological adaptations and behavioral adaptations tend to reduce energy requirements. Despite lowered metabolic and activity rates, most wintering ungulates normally lose weight. Responses of ungulates to human recreation during this critical period range from apparent disinterest to flight, but every response has a cost in energy consumption. Snowmobiles have received the most attention compared to other wintertime disturbances, and the majority of reports dwell on negative aspects of snowmobile traffic. However, snowmobiles appear less distressing than cross-country skiers, and for several ungulate species, the greatest negative responses were measured for unpredictable or erratic occurrences. In addition to increasing energy costs for wintering animals, recreational activity can result in displacement to less desirable habitats, or in some situations, to tolerance of urban developments. Tendencies to habituation vary by species, but habituated ungulates are almost always undesirable. Managers can provide an important contribution to energy conservation by reducing or eliminating disturbance of wintering ungulates and restricting recreational use of spring ranges that are important for assuring recovery from winter weight loss. During summer, the biological focus for ungulates includes restoring the winter-depleted body condition and accumulating new fat reserves. In addition, females must support young of the year and males meet the energy demands of horn and antler growth. The potential for impacts increase and options for acquiring high quality nutrition, with the least possible effort, decline as the size of the area affected by recreationists expands to fill an increasing proportion of the summer range. Disturbance of the highly productive seeps and wet sites may cause animals to withdraw to less productive areas. In addition, ungulates may be especially vulnerable to disturbance around special habitat features, such as salt licks. Persistently high levels of recreational use and the proximity to human population centers is predicted to impact reproductive performance of ungulate populations, but little direct research at this level of disturbance has been reported. Recreational traffic on and off roads has been linked with high rates of establishment and spread of noxious weeds in wildlife habitat. The importance of summer range to most ungulate populations has gone unrecognized for many years. It is apparent, however, that managers can contribute substantially to the health, productivity, and survival of these populations by reducing human disturbances to summering animals. Big game hunting has more immediate effects on ungulate population densities and structures than any other recreational activity. Hunting season security and management affects short and long-term hunting opportunities. Managers of public lands control only a few of the potential variables that contribute to security; including retention of important vegetative cover, travel management, and enforcement of travel regulations. There is a strong relationship between adequate security and predicted buck/bull carryover, but excessive hunter numbers will overwhelm any level of security. Hunting also has the potential to negatively affect herd productivity as mature males are lost from populations. Violations of ethical considerations including the concept of “fair chase” and the perception of the “sportsman” in the public mind, can increase ungulate vulnerability as well as influence social acceptance of the sport of hunting. Pursuit of pronghorns with ORVs and killing of trophy animals within game farm exclosures are presented as ethical violations.

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INTRODUCTION

Ungulates, primarily deer and elk, but also pronghorn, moose, bighorn sheep, and mountain goats, provide a large percentage of the recreational opportunities for wildlife enthusiasts in the State of Montana (MFWP 1999:37). According to Montana Fish, Wildlife and Parks (MFWP), deer hunters spend an average of 1.2 million hunter days afield per year; elk hunters spend an average of almost 900,000 hunter days afield. In addition, ungulate populations provide substantial economic benefits. The estimated annual economic value of hunting deer, pronghorn, and elk is about $360 million (Brooks 1988, Duffield and Holliman 1988 [adjusted to 1998]). Nonhunting wildlife viewing and photography generates another $53 million in trip-related expenditures (MFWP 1999:37). People who live in Montana and those who come as visitors value our ungulate populations.

Hunting is the primary tool used by MFWP to manage ungulate populations. The department's current program emphasizes hunting as a traditional use of Montana's game species (MFWP 1999). In addition, hunting is used to control big game numbers on private land at levels that minimize game damage. To increase landowner tolerance for big game animals and to minimize big game damage, it is advantageous for land managers to work with wildlife managers to reduce displacement of animals from public to private lands. In the material presented in this review, we have assumed that successful wildlife management in Montana cannot occur without continuous coordination and cooperation between the public and private agencies and individuals responsible for both the animals and the habitats in which they live.

Recreational activities on public lands have the potential not only to displace ungulates to private land where they may cause damage, but also to have negative direct and indirect effects on the populations themselves (Knight and Cole 1995). Wildlife responses to disturbance are shaped by 6 factors: type of activity; predictability of the activity; frequency and magnitude of the activity; timing (e.g., breeding season); relative location (e.g., above versus below on a slope); and the type of animal including size, specialized versus generalized niche, group size, and sex and age (Knight and Cole 1995).

To discuss potential effects of recreational activities on ungulate populations, we have focused on seasonal biology. Discussion of relevant literature and recommendations for recreation management are given for Winter/Spring, Summer, and Hunting Season. Each of these three seasons has distinct characteristics and biological limitations or considerations that influence the nature of the impact of recreational activities on ungulate populations. Management guidelines are based on our interpretation and synthesis of the available literature.

WINTER/SPRING

For many species of northern ungulates, winter range is traditionally considered the limiting factor of environment. According to Smith and Anderson (1998:1043), winter survival was reported to regulate, in a density-dependent fashion, both red deer on the Isle of Rhum, Scotland (Clutton-Brock et al. 1985), and northern Yellowstone National Park elk (Houston 1982, Singer et al. 1997). Animals that may have occupied thousands of acres of summer/fall range can be seasonally confined to relatively restricted geographic areas on which forage is limited and environmental conditions can cause physiological stress. As defined by Mackie et al. (1998:27) this is “maintenance habitat,” environments that provide “. . .all resources necessary for adult survival, but not necessarily recruitment of young.” The number of animals that can be successfully maintained in limited geographic areas is further limited by “. . . developments such as reservoir impoundments, subdivisions, access roads, highways, and the cultivation of land for agriculture. . . .” (Skovlin 1982:372).

Typically, winter ranges of elk and deer are south- and southwest-facing, low elevation slopes (Skovlin 1982) and the bottoms of large valleys (Telfer 1978) somewhat removed from areas occupied during the summer. The determining variable, however, is snow depth, and Mackie et al. (1998) have pointed out that deer populations winter where the least snow falls. “Snow impedes movement, increases energy expenditure, and reduces forage availability.” (Parker et al. 1984:479). Energy expenditures for locomotion in snow increase curvilinearly as a function of snow depth and density. As an example, Parker et al. (1984) found that a 100-kg elk calf required five times more energy when moving through 58 cm of snow than on bare ground. Snow cover greater than 30 cm can have substantial influence on the ability of elk to meet daily energy requirements (Wickstrom et al. 1984), and “. . . average snow depths beyond 25 cm are sufficient to discourage occupation of a given area by deer” (Parker et al.

1984:483). Leege and Hickey (1977) reported that elk in north Idaho selected winter range with snow depths under 2 feet if possible, and Sweeney and Sweeney (1984) found that elk avoided areas with 70 cm of snow when possible. Goodson et al. (1991) reported that even small amounts of snow had an important negative effect on foraging efficiency and diet quality for bighorn sheep.

For some elk and deer herds, there may be major migratory movements from summer to winter range. Hoskinson and Tester (1980) also reported migration of pronghorn from low-elevation winter ranges to summer ranges near the heads of valleys, and Bruns (1977) observed a southward movement during an exceptionally severe winter. However, pronghorn, moose, mountain sheep, and goats usually occupy the same geographic area year-around, while limiting winter access to specific topographic niches within the area. Rudd et al. (1983) observed that elk in Yellowstone National Park began to migrate when snow depths reached 20 cm, but Sweeney and Sweeney (1984) concluded that 40 cm was required to produce movement in Colorado. Telfer (1978) suggested that moose, being more tolerant of deep snow, simply settle into that part of their habitat with the heaviest browse biomass.

Wickstrom et al. (1984:1299) concluded that net energy intake depends on forage abundance, leaf and bite size, and digestibility of the diet. These considerations become even more important when it is recognized that almost 40% more food is required in winter to generate energy for daily metabolic and activity requirements (Nelson and Leege 1982:327). Few winter ranges are capable of providing forage increases of this magnitude. Among the rare exceptions, Mackie et al. (1998:57) reported on some Montana white-tailed deer that had access to highly nutritional crop residues. On this diet, deer continued to exploit agricultural fields even when wind chill temperatures dropped to -60^{o} C. Normally, winter ranges cannot be described in terms of forage production or quality alone. Instead, it is generally recognized that only under mild conditions will the energy gained from native forage offset energy lost from increased exposure and mobility associated with feeding (Wood 1988).

Natural Physiological and Behavioral Adaptations

Winter ranges have been most often evaluated through food habits studies and surveys of forage production. Indeed, Mackie et al. (1998:1) have pointed out that deer management in Montana has been based on a winter range conceptual model for more than 50 years where ". . . the key elements were winter range, the quantity and quality of forage (i.e., browse) available on primary wintering areas, and deer numbers and distribution relative to these resources." Various studies (Wallmo et al. 1977) have shown that native forages available in winter are mostly too low in nutritional value to meet maintenance needs of deer, which explains the limited fit of the model to observed population performance. Nelson and Leege (1982:347) may have expressed a more appropriate ecological model for many ungulates when they wrote, "Elk move to ranges where snow depth is minimal, and exist there on whatever forage is available." Mackie et al. (1998:30) observed that, "Deer survive primarily by supplementing energy reserves accumulated prior to winter with energy intake from submaintenance winter diets." This requires behavior that emphasizes energy conservation. Skovlin (1982:379) credits Beall (1974) with the observation that cold-climate ungulates ". . . seek habitats with microclimates that furnish the greatest comfort with the least expenditure of energy."

Research describing the energetic requirements and metabolic rates of various ungulates during the winter period demonstrates major physiological adaptations to winter stress. McEwan and Whitehead (1970) reported that caloric intake for caribou was 35-45% lower in winter than during the summer growth period, and similar reductions have been reported for other ungulates. Chappel and Hudson (1978), for example, found that voluntary forage intake by bighorn sheep decreased in mid-February to 0.55 of intake in mid-October. Moen (1978) reported that ecological metabolism for white-tailed deer was lowest in winter and highest in the summer, and Chappel and Hudson (1980) found that metabolic rate decreased with temperature and fasting in bighorn sheep. According to Silver et al. (1969), the fasting metabolic rate of white-tailed deer is 1.5 times greater in summer than in winter. In moose (Regelin et al. 1985), mean heat production in summer exceeded heat production in winter by a factor of 1.4. These examples all demonstrate a general physiological adaptation in ungulates that reduces energy requirements when winter survival is at stake.

In addition, most ungulates demonstrate behavioral adaptations related to energy conservation. The energy cost of standing is 25% greater than the lying posture for elk (Parker et al. 1984), moose (Renecker and Hudson 1986), pronghorn (Wesley et al. 1973), and roe deer (Weiner 1977). "Wherever behavioral patterns have been recorded, elk selection of winter resting and feeding sites has been more critical to maintenance of constant body temperature than selection of forage sites." (Lyon and Ward 1982:472). Such selections might include any of several energy conservation behaviors reported for deer (Moen 1976), including reduced activity levels, selection of areas with lesser snow, and walking slowly. Wood (1988 in Mackie et al. 1998:58) reported that foraging was energetically inefficient for mule deer during severe winter weather conditions. Bedding in protected sites was the favored strategy because it conserved energy.

One of the less desirable behaviors noticed for several ungulate species has been habituation to human habitations. Thompson and Henderson (1998) reported an increasing occurrence of elk not responding to predictable and harmless human activities on winter ranges in the urban fringe. They noted that the habituation response was an adaptive behavioral strategy promoted by the need to conserve energy, avoid bodily damage, out compete other individuals, and find unutilized resources. Human tolerance for some smaller ungulates like deer is fairly high, as evidenced by management planning to maintain an urban population (Shoesmith and Koontz 1977), but it is doubtful there is very much tolerance for larger species like elk and moose.

Finally, the importance of certain physical attributes of winter ranges should not be overlooked. Beall (1974) detected and reported consistent patterns of bedding site selection in which elk regularly utilized the largest available tree in any situation. Ryder and Irwin (1987) reported that larger shrubs, steep slopes, and irregular topography were important determinants of winter habitat use for pronghorn, thus confirming Martinka's (1967) observation of starvation for several hundred pronghorn restricted to a grassland vegetative type while pronghorn on adjacent ranges where sagebrush was present suffered only minor losses. Bruns (1977) reported pronghorn that selected microhabitats with more favorable conditions than the average for the study area enjoyed 63% lower wind velocities, 24% less snow, and 87% softer snow. Similarly, "By use of shelter associated with badlands topography, mule deer reduced conductive heat loss by 47 percent at feeding sites and by 61 percent in bedding sites." (Mackie et al.1998:57).

Energetic contributions of thermal cover have been widely assumed as valuable in winter, but a recent monograph by Cook et al. (1998:5) concluded there was no positive effect of thermal cover on elk. Instead, they found that dense cover provided a ". . . costly energetic environment, resulting in significantly greater overwinter mass loss. . ." These authors also reported that previous studies of winter thermal cover for white-tailed deer (Robinson 1960, Gilbert and Bateman 1983) and mule deer (Freddy 1984*b*, 1985, 1986*b*) had reached similar conclusions. They suggested that habitat managers should give more attention to forage relationships and vulnerability of ungulates to harvest and harassment.

For some large ungulate species, winter separation of sex and age groups has been reported. Geist and Petocz (1977) suggest that bighorn sheep males segregate from females to minimize competition and disturbance for mothers of their prospective offspring. Both sexes occupy a continuous range but concentrate in different areas. Mackie et al. (1998:39) reported a similar separation in both species of deer. Dominant breeding males, ". . . in poor condition following the energy-costly rut . . ." select winter habitats to conserve remaining fat reserves. Unsworth (1993) reported a complete separation of elk in Idaho, with bulls using more open timber habitats and less shrubfield types than cows and calves. Leege and Hickey (1977) described a similar separation, but they also noted there was competition for forage between adult bulls and other elk.

<u>Natural Physiological Manifestations and Ramifications</u>

For all ungulates, winter is a difficult time in which stresses imposed by deep snow, forage shortages, and low temperatures depress the body condition of even healthy animals. One obvious manifestation of severe winter weather is loss of body weight. Weight loss occurs even in normal winters and on the most productive winter ranges. Nelson and Leege (1982:330), quoting Gerstell (1937), report ". . . that white-tailed deer in Pennsylvania were not able to maintain body weight at temperatures below -1 degree Celsius regardless of the quality or quantity of diet." It is generally accepted among biologists that weight loss approaching 15% during the winter is normal for many ungulates. Mautz (1978) wrote that deer frequently lose up to 20-30% of their weight over the winter. Youmans (1992:5) indicated that winter stresses ". . . can result in a 20-25% loss in body weight for an adult.", but Cook et al. (1998:42) reported that weight loss of 18-20% in elk calves sometimes resulted in death.

Weight loss does have a cost, however. Thorne et al. (1976) found that weight lost by elk cows during pregnancy was significantly correlated to calf weights at birth and subsequent growth rates through the fourth week. Captive elk that lost more than 3% of body weight between January and calving produced lighter-weight calves with a reduced probability of survival. Smith and Anderson (1998:1042), on the other hand, wrote, "Contrary to our expectations, we found no correlation between birth mass of individual calves and their survival. However, survival was positively correlated with mean cohort birth mass." The effect of undernutrition on reproduction, birth mass, and survival of calves was also identified as determining population trends in the northern herd of Yellowstone National Park. Houston (1982:44) reported that elk migrating down the Yellowstone River and out of the Park tended to show higher calf/cow ratios in winter than elk that remained within Yellowstone. Whether these differences were due to hunting outside the Park or to less severe snow conditions at lower elevations could not be determined.

Pregnant females are obviously affected by weight loss during winter, although much recent research has suggested that body fat accumulated during the summer is more important than winter weight loss in determining the outcome of pregnancy. In an investigation of embryonic mortality in caribou, Russell et al. (1998:1073) found that maternal fat and body mass determined probability of pregnancy and postulated that ". . . embryonic mortality occurs very close to the breeding season,. . . " rather than late in pregnancy as a result of poor winter diet. Even though winter weight loss may be severe, Nelson and Leege (1982:328) observed that for elk, "Serious demands on the cow do not occur during the first 170 days of gestation." Nearly 70% of weight gain in a developing fetus occurs during the last 80 days of pregnancy (Bubenik 1982:171 [using data from Morrison et al. (1959)]). Thus, spring green-up may be the most important winter forage resource for pregnant elk.

The importance of spring range in assuring recovery from winter weight loss has not been appropriately emphasized in the literature. Even with warming temperatures and reduced snow depths, early spring reveals many ungulates at the absolute lowest physical condition of the year. Until new, green forage restores lost weight and energy, these animals may succumb to stresses that would be considered minor at other times of the year. The development of green vegetation at lower elevations on southerly slopes are also attractive for people following a long winter. A collector looking for dropped antlers, or even an early-season family picnic, can inflict major stress injury on any ungulate at this time of the year.

Physiological Impacts of Human Disturbance

The Montana Department of Fish, Wildlife and Parks has, for many years, prohibited public access to dedicated big game winter ranges between December 1 and May 15. This closure is intended to prevent disturbance and harassment of game animals during a period when physical stress is already relatively high. Managers also recognize the counterintuitive logic of compounding climatic stress with late hunting seasons, but such seasons are sometimes the only available management tool. Very often, road closures can be used as an adjunct method of reducing simultaneous disturbance by hunters and vehicles. Gates and Hudson (1979), found that activity by elk in cold temperatures results in a thermoregulatory penalty, that is, it takes more energy to move in winter than in the fall. Thus, while inactivity provides an energetic advantage for animals exposed to cold, forced activity caused by human disturbance exacts an energetic disadvantage. Geist (1978) further defined effects of human disturbance in terms of increased metabolism, which could result in illness, decreased reproduction, and even death.

The overt expression of this cost can take a number of forms, ranging from an increase in general alertness to a slow retreating movement to outright flight, depending on the ungulate species and the type of disturbance. Denniston (1956) reported that moose were tolerant of close observers when no quick motions or loud noises were made, but LeResche (1966) observed a number of different reactions ranging from flight, to drifting away, to disinterest.

Of the ungulate species for which relationships with humans and disturbance have been reported, the bighorn sheep appears to be most susceptible to detrimental effects. Berwick (1968) suggested that harassment may be debilitating to winter-stressed animals, and several other authors have agreed. Geist (1971) speculated that harassment by recreationists may be fatal to sheep, and Dunaway (1971) considered disturbance caused by human recreation to be a factor limiting populations of bighorn sheep in California. Stemp (1983), who used observations as well as heart rate data to monitor response to harassment, reported that overt behavior was a poor indicator of the stress response of bighorn sheep to human intruders.

Specific investigations of winter disturbance have primarily examined skiers, snowmobiles, and, to a lesser extent, helicopters. Snowmobiles have received far more attention than all other disturbance factors combined, and the reports, not unexpectedly, express the complete range of possible results. Bollinger, et al. (1972) reported that deer activity increased when snowmobiles were present, but deer were not driven out of their normal home range. Lavigne (1976) reported that snowmobile trails enhanced deer mobility during periods of deep snow in Maine. This study was followed by a report (Richens and Lavigne 1978) that white-tailed deer were not driven out by snowmobiles, but were following snowmobile trails because the snow was firmer. In a slightly more negative series of studies, Eckstein and Rongstad (1973), Dorrance et al. (1975), and Eckstein et al. (1979) found that while some deer showed avoidance when snowmobiles were present, there were no significant changes in home range or daily movement patterns. Doyle (1980) summarized two studies reporting negligible impacts by snowmobiles on the environment.

The majority of reports on this subject, however, dwell on negative aspects of snowmobile traffic. Malaher (1967) complained that snow machines were illegally used for hunting, while Neuman and Merriam (1972) reported the loss of insulating quality in snow packed by snowmobiles as well as damage to vegetation. Baldwin (1970) suggested a luxury tax on snowmobiles for the damage they cause. Fancy and White (1985) found that the energy cost for caribou of cratering through snow compacted by a snowmobile was 2-4 times as great as for uncrusted snow. Other authors have reported disturbance of wild animals as disparate as muskoxen (McLaren and Green 1985), caribou (Fancy and White 1985), and white-tailed deer (Kopischke 1972, Moen et al. 1982,). Huff and Savage (1972) reported that the size of home ranges for whitetails was reduced in high-use areas, and snowmobile use appeared to force deer into less preferred habitats. Aasheim (1980) observed that animals accustomed to humans are less affected by snowmobiles than animals in more remote areas.

Apparently, however, snowmobiles are less disturbing than cross-country skiers. Freddy (1986*a*) and Freddy et al. (1986), found that responses by mule deer to persons afoot, when compared to snowmobiles, were longer in duration, more often involved running, and involved greater energy costs. Aune (1981) classified responses of wildlife to winter recreationists in Yellowstone National Park as attention or alarm, flight, or, rarely, aggression. He agreed with Chester (1976) in concluding that winter recreational activities were not a major factor influencing wildlife, although minor displacement was observed. Such displacement might have indicated only movement away from active ski trails, as reported for elk by Ferguson and Keith (1982) in Elk Island National Park, Alberta, but it could also have involved overwinter displacement as reported for Elk Island moose (ibid.). Almost certainly because of increasing recreational pressure in Yellowstone National Park, Cassirer et al. (1992) found that 75% of flight behavior by elk occurred within 650 m of skiers and recommended that restrictions be imposed. Parker et al. (1984:484) observed, "Flight distances decline from early to late winter as the animals become habituated and as body energy reserves are depleted. Greater flight distances occur in response to skiers or individuals on foot than to snowmobiles, suggesting that the most detrimental disturbances to the wintering animal is that which is unanticipated." This greater response to unpredictable or erratic disturbance was also noted for pronghorn (Segerstrom 1982) and bighorn sheep (Stemp 1983).

Most research testing helicopter disturbance to wildlife has been related to oil exploration activities. However, these data can be applied to some recently popular winter skiing activities. Bleich et al. (1994) recorded negative responses of bighorn sheep to helicopter overflights. Joslin (1986b) reported a decline in mountain goat reproduction and/or recruitment of kids in response to disturbance by helicopters in Montana, and Côté (1996) reported that mountain goats were disturbed by 85% of all flights within 500 m. Foster and Rahs (1985) have even suggested that localized goat mortality and temporary range abandonment is a result of hydroelectric exploration activities. Luz and Smith (1976) found that pronghorn responses to helicopters varied from mild to strong in relation to decibel levels.

The degree of disturbance caused by skiers, snowmobiles, and helicopters has mostly been reported in terms of flight distance or in some observed change in behavior manifested by animals. Based on elk heart rate data, Chabot (1991) showed that even when disturbances do not induce an overt behavioral response, the increased heart rates can result in relatively high energy expenditures. These results have been confirmed and expanded for a variety of ungulates including mule deer (Freddy 1984*a*, Weisenberger et al. 1996, Freddy 1977), caribou and reindeer (Nilssen et al. 1984, Fancy and White 1985, Floyd 1987), white-tailed deer (Moen 1978, Moen et al. 1982), elk (Ward and Cupal 1979, Lieb 1981, Chabot 1991), red deer (Epsmark and Langvatn 1985, Herbold et al. 1992, Price and Sibly 1993) and bighorn sheep (MacArthur et al. 1979, MacArthur et al. 1982, Stemp 1983, Geist et al. 1985, MacArthur and Geist 1986, Hayes et al. 1994**)**. In summary, it has been shown repeatedly, and for virtually every ungulate species, that even minor, seemingly harmless sorts of disturbance cause increased heart rates -- and increased energy expenditure.

Displacement Impacts

In addition to the obvious energy costs, continuing disturbance by humans can result in a variety of insidious effects that are less easy to document. Canfield (1984) noted that effects of increased access associated with a high-voltage powerline were accentuated because of the placement of the powerline corridor in open wintering areas and on the edge of the timber that separated bedding and feeding areas. Vogel (1983) reported that white-tailed deer inhabiting more developed areas became increasingly nocturnal and secretive and made greater use of cover during the day. Canfield (1984), based on 24-hour telemetry work, found that elk utilized the more open, productive habitats in close proximity to human activity nocturnally. Similarly, Morgantini and Hudson (1979) reported that harassment by vehicle activity and the hunting season reduced elk use of open grassland and resulted in overgrazing of marginal areas. Yarmoloy et al. (1988) were able to demonstrate how little disturbance was required to produce such modified behavior. They reported a study in which intentional harassment of three mule deer does for 9 minutes/day for 15 days in October caused the deer to begin feeding at night and using cover more frequently. They also suggested a secondary effect through reduced reproduction.

Another potential result of disturbance or harassment of wintering animals can be movement from historical and accepted winter ranges (usually on public land) to private lands where haystacks and forage for domestic livestock are at risk. Rognrud and Janson (1971) reported damage to private property after natural food plants on the winter range had been eaten by elk.

There are also situations in which flight and/or displacement are not possible, and, for lack of other options, animals become habituated to disturbance. Morrison et al. (1995) reported responses of elk to ski area development in Colorado were negative, but not as great as predicted. In part, this may have been evidence of habituation of the kind reported by Schultz and Bailey (1978) in which elk wintering adjacent to Rocky Mountain National Park often used a residential area at night and were little disturbed by normal visitor traffic on roads. Most species represent some risk to humans, and in many cases the damage to residential landscape vegetation is untenable. Habituation at this level can be far more serious than is usually suggested by complaints about damage to landscape plantings (Thompson and Henderson 1998). Once habituated to urban environments, ungulate populations are very difficult to control. In both Colorado and Montana, habituated white-tailed deer have attracted mountain lions to the edges of housing developments, thus increasing the risk to both humans and their pets.

Conclusions

Based on the available research, wildlife and land managers have little reluctance in recommending that human disturbance of wintering animals be prevented. We propose the following guidelines as minimum acceptable considerations for protecting ungulates on Montana winter ranges. In addition, we believe there should be management flexibility in application depending on the degree of winter severity. Such flexibility could be used to trigger emergency restrictions in specific situations.

Guidelines/Recommendations

Management techniques that reduce human disturbances on ungulate winter range include the following, by priority:

1. Route winter-use facilities, trails, and/or roads away from ungulate wintering areas (this may include high-elevation areas used by some sex and age classes or during mild conditions).
2. Establish designated travel routes within area closures where recreation occurs on or across winter ranges (no off-road/trail use) to make human use of wintering areas as predictable as possible (if needed, use could be restricted to mid-day time frames, dogs could be restricted of excluded, and low speed limits could be imposed on snowmachines). Examine routes to ensure that bedding and feeding areas are not separated, that open ridges are avoided, and that topography serves to buffer noise and disturbance.
3. Monitor ungulate use of areas that receive high-impact winter use by snowmobiles and/or skiers and identify and mitigate any potential conflicts.

4. Actively enforce travel restrictions on ungulate winter ranges.
5. Use interpretive signing to inform users of the importance of ungulate winter range and that they should not approach wildlife closer than 150 m.
6. Restrict antler collection and other recreational activities with potential to displace ungulates during spring green-up until at least May 15th (preferably leaving some flexibility, based on snow conditions, to allow animals to disperse naturally from their traditional winter concentration areas).

Information Needs

Parker et al. (1984:486) concluded that "Unnecessary energy expenditures . . . can be limited by minimizing human disturbances." Standards for preventing disturbance, however, have been variable. Severinghaus and Tullar (1975) concluded that snowmobiles should not be allowed in wintering areas and trails should be kept at least one half mile from such areas. Freddy et al. (1986) concluded that preventing locomotor responses would require persons afoot and snowmobiles to remain >191 m and >133 m, respectively, from mule deer. Côté (1996) recommended restriction of helicopter traffic within 2 km of alpine areas and cliffs that support mountain goat populations. Additional research might establish an absolute minimum disturbance formula for each species, but we recommend an overall conservative approach as more useful to managers.

SUMMER

Ungulate physiology and behavior favor physical development and fat accumulation in both sexes during the biological season after birthing (e.g., early June through October). Adult males must build fat reserves for the fall breeding season while meeting energy demands of horn and antler growth. Males of all ungulate species grow either antlers or horns, and in several species the growth rate is one of the spectacular events in nature. Adult females must obtain forage of adequate quantity and quality to meet energy demands of lactation while simultaneously recovering from weight lost during the previous winter and building fat reserves for the coming winter. It has been more than 30 years since Verme (1967:419) suggested, ". . . that the quality of spring, summer, and fall foods of the whitetail might be more important than many people think in determining the number of future targets for the hunter." A decade later, Mautz (1978:90) observed, "It was at first a logical conclusion that research emphasis should be put on that time of the year where weight loss occurs and mortality is most evident. It appears now, however, that the major emphasis should be shifted from the analysis of the nutritive value of winter foods to studies of summer and fall food availability and digestibility and other factors influencing the accumulation of body fat."

Verme's (1965) research with penned white-tailed does on controlled diets showed that starvation during summer caused a late and irregular rut, yielding 0.95 fawns per doe while well-fed deer had 1.74 fawns per doe. More recently, Hines et al. (1985), in a controlled test of yearling bull breeding efficiency, found that breeding deficiencies were related to the level of fat reserves stored by females. Parker et al. (1999) have concluded that reserves accumulated during summer were critical to winter survival of black-tailed deer, and Cook et al. (1996) reported that forage intake and nutritional quality during August and September can be determinants of winter survival of elk calves.

Prior to restoring their own body condition, many female ungulates must also support young of the year. Moen (1978) estimated energy expenditure of a white-tailed doe with twin fawns at four times baseline metabolism during lactation, and Carl and Robbins (1988) have found that energetic costs in deer were five times greater to the doe than to the neonate.

For virtually all ungulate species, habitats available during summer represent a substantial increase in geographic area as compared to winter range. Some ungulate species access high-quality forage throughout summer by migrating upward in elevation to feed on vegetation in early phenological stages and/or by withdrawing to areas surrounding seeps, springs, and other wet sites within seasonal home ranges where vegetation remains highly digestible. Lieb (1981) reported that elk expanded their home range from spring through midsummer and thereafter reduced areas of use through early fall. A few ungulate species, in particular mountain goats and bighorn sheep, are very much limited in habitat choices by topography. Thus, even though the total extent of summer habitat is usually not limiting, the important features of the habitat may be limiting (Leege 1984).

Natural Physiological and Behavioral Adaptations

During summer, ungulates continue to follow the law of least effort as a strategy for retaining and storing as much energy as possible (Geist 1982). However, recreationists can impact this effort through either direct disturbance of animals or by disrupting access to essential forage resources. Energetic costs of disturbance have been well described for winter conditions, but not nearly as well for the summer period. Costs of locomotion are much less than during periods of deep or crusted snow in winter, but energetic demands of the summer season are relatively higher than generally recognized because most ungulates are more sensitive to heat than to cold. Chappel and Hudson (1978) reported resting metabolic rates of caribou were lowest in February and highest in May. Renecker and Hudson (1986) reported moose are easily heat stressed, and that respiration rate increased above 14^{o} C. Lieb (1981) reported elk activity was reduced after temperatures exceeded 75^{o} F.

Physiological Impacts of Human Disturbance

Several authors (McMillan 1954, Denniston 1956) have reported moose tolerance of observers when no quick motions or loud noises were made. Bansner (1976) has reported a similar observation for mountain goats, and Goodson (1978) found that bighorn sheep were more tolerant in areas where they are accustomed to seeing people. Miller and Smith (1985), however, reported that sheep exhibited stronger reactions to 1 or 2 humans on the ground than to parked vehicles or a light airplane circling overhead. Controlled experiments with elk, pronghorn, and bighorn sheep (Bunch and Workman 1993) resulted in habituation for most disturbance factors tested. The exceptions were people on foot and aircraft at low elevations. In California, black-tailed deer in a vehicular recreation area were reported to avoid active OHV areas during peak use, but returned to established home ranges after traffic levels subsided (Ferris and Kutilek 1989).

Any apparent level of tolerance, however, may be misleading. MacArthur et al. (1982) reported responses to disturbance of bighorn sheep were detected using heart-rate telemetry that were not evident from behavioral cues alone. The appearance of a human within 50 m of sheep resulted in a 20% rise in mean heart rate (MacArthur et al. 1979). Stemp (1983) also reported increased heart rates in bighorn sheep relative to human intruders in their habitat. As an isolated event, such a disturbance is probably not significant, but the energy costs associated with repeated disturbance can be considerable.

Ungulates may be especially vulnerable to disturbance around special habitat features, such as salt licks. For example, female and young mountain goats make daily trips to salt during periods of the summer, sometimes venturing several hundred meters from escape terrain (Thompson 1981). Kids may face increased risk of separation from nannies while fleeing when surprised or distracted by humans on a salt lick as well as higher mortality if not reunited. Although wild ungulates normally do not require supplemental salt, they will use salt placed within their summer home ranges and may be baited into traps with salt placed by researchers. Hamilton et al. (1982) reported that bighorns did not abandon habitat because of recreational use but did avoid an important lick when people were present. Sites where salt is or has been placed for cattle often attract ungulates and are accessible viewing areas for general recreationists and wildlife photographers. Potential impacts on the survival of individual animals are heightened under such circumstances.

Displacement Impacts

Perhaps more important than the short-term energetic effects of human disturbance are the longer-term influences of displacement from selected habitats. Relatively high levels of human disturbance are often confined within a narrow corridor through wildlife habitat, such as a road. These may have little or no measurable impact on ungulates during summer if essential foraging sites are not directly impacted or limited in availability across the summer home range. However, a substantial number of studies have demonstrated that vehicle traffic on forest roads does establish a pattern of habitat use in which the areas nearest the road are not fully available for use by elk (Ward et al. 1973; Rost and Bailey 1974, 1979; Rost 1975; Marcum 1976; Perry and Overly 1976; Thiessen 1976; Ward 1976; Lyon 1979*a*, 1983; Edge 1982; Edge and Marcum 1985,1991; Edge et al. 1987; Marcum and Edge 1991). The extent of reduced habitat use can be very substantial. With only two miles of roads open to vehicular traffic per square mile, the area affected can easily exceed half of available elk habitat (Lyon 1983).

Once the original purpose of a forest road is satisfied (normally a timber sale), management agencies tend to assume that daily traffic is primarily recreational in nature. Accordingly, many roads have been gated under the assumption that limited use by "administrative traffic" will not unduly disturb elk and other wildlife. Unfortunately, this assumption is untrue, and even a limited amount of administrative traffic behind closed gates provides more than adequate reinforcement of the avoidance behavior (Lyon 1979*b*).

As the size of the area affected by recreationists expands to fill an increasing proportion of the animals' summer range, the potential for impact increases because options decline for acquiring high-quality nutrition with the least possible effort. In some cases, there may be no options available. Populations of mountain goats and bighorn sheep, for example, are often confined to relatively narrow bands of suitable habitat associated with very steep and rocky slopes. Population impacts may be expected where summer recreation is concentrated in such areas. Kuck (1986) reported, ". . . that elk, deer and moose may be capable of adapting to many phosphate mining activities in southeastern Idaho, but cannot compensate for disturbance on important seasonal ranges. . . " such as those used for calving and winter migration. Similarly, Lieb and Mossman (1966) found that human disturbance caused Roosevelt elk with young calves to move to secondary forage areas away from the central parts of their home ranges. In Colorado, Phillips (1998) was able to show that repeated displacement during the calving season resulted in major declines in survival of elk calves. He recommended that recreational traffic be routed away from areas in which elk were known to calve. In Montana, summertime occurrences of known human recreational impacts on reproductive performance in ungulate populations have been limited to relatively few situations and circumstances, but managers need to be aware of the potential problems.

Bear and Jones (1973) reported that camping, hiking, and ORVs negatively influence sheep distributions and activities. Many other authors have confirmed these observations and recommended regulating ORV use and human activities where they affect sheep (Tevis 1959; Wilson 1969, 1975; Dunaway 1971a; Geist 1971b; Graham 1971, 1980; Demarchi 1975; DeForge 1976; Douglas 1976; Horejsi 1976, 1986; Elder 1977; Hicks and Elder 1979; Thorne et al. 1979; Leslie and Douglas 1980; Skiba 1981; Hansen 1982; Stevens 1982; Stemp 1983; King 1985; King and Workman 1986; Krausman and Leopold 1986a; Stockwell et al. 1991; and Harris et al. 1995a). Wehausen et al. (1977), however, concluded that human disturbance was not as important as previously assumed.

Areas of intensive summer recreation, where they occur in the urban interface or very near cities, are often crisscrossed by many miles of trails across thousands of acres of summer habitat for deer and elk. Persistently high levels of forest recreational use by hikers, joggers, mountain bikers, and Frisbee golfers are fueled by close proximity to a major human population center. Where summer recreational activities approach high levels, elsewhere or in the future, impacts on reproductive performance of ungulate populations may be expected. However, little direct research describing this level of disturbance has been reported. Bullock et al. (1993) recorded the responses of deer in two English deer parks and reported encounter rates with people, dogs, and vehicles between 6 and 40 per hour. Resulting withdrawal percentages by deer were less than 10%. Areas of potential concern for the future include increasing development of summer recreational facilities at high-elevation ski areas and development of expansive forest trail networks for mountain bikers. Morrison et al. (1991) discovered that ski-area development caused elk to partially abandon the area developed along with a concurrent reduction of timbered-habitat use from 80-95% down to 20%. In a follow-up study, Morrison et al. (1995) compared two ski-area developments and found that physical disturbance caused a 30% reduction in elk use of one area while human activity in another area led to 98% reduction in elk use. Recreational use may also alter migratory movement patterns of ungulates, like deer and elk, using public lands and result in situations where more time is spent on private lands.

Indirect Impacts

Under current conditions in Montana, indirect impacts on ungulates by recreationists may also be of major immediate concern. Vehicular traffic on and off roads has been linked with high rates of establishment and spread of noxious weeds in wildlife habitat. Competition from noxious weeds may reduce quality and quantity of summer forage for ungulates, resulting in poorer reproductive performance during the lifetime of an animal. Observations in western Montana have shown that noxious weeds are capable of influencing ecosystems at the landscape scale, and risks of habitat impacts are high without an aggressive program of prevention and rapid response to first weed establishment. Education and management of recreationists is a fundamental component of any weed prevention program. The potential for spreading noxious weeds across the landscape should also be a factor in the evaluation of road-closure decisions.

Conclusions

For many years, winter ranges were considered the most limiting component of ungulate environments. However, as our knowledge of ungulate physiology and behavior has increased, it has become apparent that weight gains and nutritional contributions of high quality summer range may be of equal or greater importance in determining winter survival and reproductive success. Based on our interpretation and synthesis of available literature, we propose the following guidelines for management of recreation on summer range.

Guidelines/Recommendations

Management techniques that reduce human disturbances on ungulate summer range include the following by priority:

1. Route summer recreation facilities away from key foraging areas (drainage heads, mesic areas) and consider restrictions on existing roads or trails to minimize disruption of these important areas.
2. Establish designated routes within area closures to make human use of summer range as predictable as possible.
3. Reduce human intrusions (through road or trail restrictions and/or education) into areas where ungulates are limited to easily identified habitat areas (such as areas used by bighorn sheep or mountain goats) or where limited areas of habitat are either desirable or exceptionally productive.
4. Limit open road densities to zero in scattered key areas and less than 1 mile per section elsewhere; reclaim roads that are closed and re-establish native vegetation to help keep travel violations to a minimum.
5. Minimize administrative uses of and the granting of travel variances for closed routes on summer range.

Information Needs

The effects of open roads on summer habitat use is extremely well documented for many ungulates. Our primary deviation from published literature involves the recommendation for scattered areas of zero road density to protect key summer forage sites.

HUNTING SEASON

Hunting is an important tool for managing ungulate populations. Hunting is also an important cultural activity (Posewitz 1994) that annually involves nearly half the adult male population and one-fifth of adult females in Montana (Merrill and Jacobson 1997). Big game hunting is also a major economic activity and an important contributor to the state economy (Brooks 1988, Duffield and Holliman 1988, Loomis and Cooper 1988). Hunting almost certainly has more immediate effects on ungulate population densities and structures than any other recreational activity in this state.

Little attention has been paid to possible short-term effects of the hunting season on animal condition. Because “Elk enter the fall season in near peak body condition.” (Youmans 1992:5), energetic costs of disturbance by hunters appear less important than at other times of the year. Nevertheless, there are costs.
Hurley (1994) reported that distances moved by elk between telemetry relocations in Montana increased significantly during the hunting season. And in Utah, Austin et al. (1989) reported a study in which mule deer bucks killed on the second weekend of the hunting season consistently weighed less than bucks of the same age class killed the first weekend. They blamed (p.35) “. . . hunter harassment, although other factors, including rutting activity and hunter selection, may also be important.” Flook’s (1970) observations of elk in several Canadian National Parks suggest breeding activity is not of secondary importance. He wrote (p.5), "A number of factors contribute to shortening the life span of bulls, probably a major one being the depletion of their fat reserves during the breeding season in the autumn. This leaves bulls less well prepared to survive the winter." In addition, both Irwin and Peek

(1979) and Lyon and Canfield (1991) have reported elk displaced by hunters from preferred areas to areas of larger patches and less diversity.

Longer-term effects of hunting on population structure and productivity are relationships best understood for deer and elk. They involve hunter opportunity, security during the hunting season, and the resulting vulnerability of hunted animals. For many years, management plans for big game have assumed that harvest regulations can maintain populations at near optimal levels as determined by winter range carrying capacity (Leopold 1933) and landowner tolerance. As knowledge has increased, managers have broadened this perspective to recognize that among factors which influence population status, those most influential are weather, habitat condition, predation, and hunter harvest (MFWP 1998:2). Because the interrelationships of these factors are so complex, it is easy to overlook the fact that if not carefully managed, hunting recreation and hunter access can have very negative effects on the sex and age class distribution of hunted animals, on the amount and quality of hunting recreation available, and on net productivity of ungulate herds.

Hunter Opportunity

Hunter opportunity includes "An array of options that allows hunters to choose situations that are personally rewarding." (Lyon and Christensen 1992). For Montana elk hunters, maximum hunter opportunity occurs when the statewide recreation objectives for elk are met. These include a 5-week general season, a harvest in excess of 20,000 elk, about 5.5 hunter days for each of about 123,000 elk hunters, and an annual bull harvest comprised of at least 25% branch-antlered bulls (Youmans 1992:19). Deer management objectives are more complex and include an adaptive harvest management strategy (MDFWP 1995) with a variety of hunting regulation alternatives. The greatest hunter opportunity occurs when seasons are long (the current 5-week general season is considered adequate to meet the definition of long), regulations are minimal (hunters have many choices on where, when, and what they hunt), and there are good opportunities to harvest an animal throughout the season with some chance for harvesting a mature animal.

Logically, any factor that leads to shorter seasons, more regulations, and restricted age structures in populations can be considered detrimental to hunter opportunity. Conversely, conditions that allow for longer seasons, require less regulations, and help maintain desired age structures would be considered beneficial to hunter opportunity. In one way or another, conditions that contribute to increased hunter opportunity involve security during the hunting season.

Security

For elk, security has been defined as "The protection inherent in any situation that allows elk to remain in a defined area despite an increase in stress or disturbance associated with the hunting season or other human activities." (Lyon and Christensen 1992:5). And Youmans (1992:7) has declared, "Emphasis on maintaining fall security areas and secure migration corridors is essential to meeting statewide demands for public hunting opportunity, maintaining a variety of recreational experiences and maintaining a diverse bull age structure." When security is inadequate, elk may become increasingly vulnerable to hunter harvest and, as Lonner and Cada (1982) pointed out, "A lengthy hunting season has little meaning if the majority of the harvest occurs in the first few days." Thus, poor security can lead to a decrease in hunter opportunity and the inability of managers to meet objectives for sex and age structure.

One of the surest methods of increasing elk security has been to close roads and/or areas to motorized vehicles. Lonner and Cada (1982) assumed an inverse relationship between density of open roads and hunter opportunity by using the rationale that high road densities make elk highly vulnerable to hunter harvest. Basile and Lonner (1979) found that vehicle closures generally increased the time hunters spent walking and tended to prolong the time required to achieve the desired harvest. In Idaho, Leptich and Zager (1991) found a strong relationship between restricted road access and bull survival. However, security is more complex than just low road densities and can be influenced by a multitude of factors that may vary from one population or habitat complex to the next. Hurley (1994), for example, concluded that, "Restricting motor vehicle access can reduce elk vulnerability, but road closures must encompass large areas to be effective." In all cases, security is that combination of variables that provide protection for vulnerable animals during the hunting season.

Hillis et al. (1991) described the minimum-sized area providing elk security in habitat types west of the Continental Divide as a nonlinear cover patch greater than 250 acres in size and more than 1/2 mile from an open road. They defined a threshold under which 30% of forested landscapes dedicated to security would presumably provide for adequate bull carryover. They also concluded that other factors, such as topographic ruggedness, hunter-use patterns, animal-use patterns, and adjacent private-land access could significantly alter bull survival somewhat independently of the size of security patches or road density. Lyon and Canfield (1991) tested these relationships with radioed elk and found that elk selected for larger cover patches after the onset of the hunting season.

Hillis et al. (1991) cautioned that security cannot be defined by a "cookbook" recipe, but must be determined and mapped by qualified local biologists in consideration of all potential variables. In support of the concept of locally defined security variables, Weber (1996) examined a large area in western Montana to determine where hunters actually killed elk (by locating gut piles) and compared the locations against a number of security variables. He concluded that cover patch sizes described by Hillis et al. (1991) might be inadequate, and that security areas significantly greater than 250 acres might be needed if a moderate level of bull carryover is desired.

Unfortunately, environmental variables do not provide security in all cases. Unsworth and Kuck (1991) determined that increasing hunter numbers will ultimately overwhelm any level of security and result in rapid and total bull harvest. This confirms what earlier researchers in Oregon found, that road closures did not necessarily result in improved bull carryover, presumably because of the overwhelming number of hunters (Coggins 1976). Similar relationships exist for deer populations. In a management analysis of Montana deer hunting (MDFWP 1995:3), the authors concluded, ". . . although different season types can alter the age structure of a deer population, population fluctuations will still continue due to changing environmental conditions and other factors." Thus, limiting buck harvest will not consistently result in an older age structure.

And finally, Burcham et al. (1998) have described one additional security variable in the mixture managers must consider. Between 1983 and 1993, they reported increased use of private lands by elk in the Chamberlain Creek drainage of western Montana. During a period of timber harvest and a threefold increase in numbers of hunters, posted private lands acted as security for elk despite being near open roads and mostly non-forested, agricultural land. Elk that did not use these private-land refuges selected more traditional security cover of closed-canopy coniferous forest far from open roads.

In summary, the deer and elk literature shows several strong relationships between age and sex structure of ungulate populations resulting from hunting harvest and environmental factors such as roads, topography and cover. These relationships, in turn, affect short- and long-term hunting opportunities. Managers of public lands have control over only a few of the potential variables that contribute to security, including retention of important vegetative cover, travel management, and enforcement of travel regulations.

In terms of security/harvest rate/carryover issues for other species including goats, bighorn sheep, and moose, the literature is less conclusive. For mountain goats (and bighorn sheep in many circumstances), the level of security (measured by roadless, rugged topography) can be extremely high, yet the hunting success rate remains consistently high throughout the state. In this situation, the number of hunting tags issued determines the harvest, not the amount of security on the landscape. High success rates are due to the species' limited trophy-entry status and high demand and vulnerability. In some cases, the issuance of special tags for antlerless elk and deer may also result in high success rates. However, this is not always true, and managers may encounter situations where reducing security will be necessary to achieve management objectives.

Vulnerability and Productivity

"In other western states, reductions in elk security and concurrent increases in elk vulnerability have prompted substantial reductions in public hunting opportunity. . . " (Youmans 1992:9). Experiences in northeast Oregon in the 1970s and 1980s (Leckenby et al. 1991) serve as a good example of the effect that hunting recreation can have on ungulate productivity when the quarry is overly vulnerable. Reports by the Oregon Department of Fish and Wildlife were mostly limited to elk, but their experience should serve as a caution for management of other ungulates relative to disruption of normal breeding dynamics.

Elk hunting opportunity declined drastically in northeast Oregon in the late 1980s as a result of ". . . increased public access and reductions in cover. . . ." (Leckenby et al. 1991:89). In the early 1970s many hunting districts in northeast Oregon had little if any bull carryover. Attempts to improve bull carryover through road management largely failed (Coggins 1976). Because of low bull/cow ratios and declining calf recruitment, the Oregon Department of Fish and Wildlife shortened seasons, split seasons, and limited numbers of hunters. At about this same time, Smith (1980) reported a strong correlation between the presence of older males in the breeding population and significantly higher pregnancy rates in Roosevelt elk of the Olympic Peninsula. In an Oregon study a few years later (Hines et al. 1985) concluded that is it not prudent to depend on yearling breeders, that a few older bulls are needed to ensure maximum herd productivity, but that pregnancy rates are actually determined by nutritional level among the cows. Following studies of breeding by known-age bulls in the captive Starkey elk herd, Noyes et al. (1996) explained the Oregon elk decline with the following rationale:

1. High hunter numbers and limited security results in a long-term total bull kill.
2. Yearling bulls (protected as calves during the preceding hunting season) must do 100% of the breeding.
3. Inexperience and immaturity of those bulls cause most cows to breed at the second estrus, which means that calves are born late.
4. Younger calves have reduced body weight going into their first winter.
5. Consequently, there is lower overwinter survival and overall reduced productivity.

Fortunately, there has been no indication that any Montana elk herd is in decline because of poor bull carryover. In the Gravelly Range, one of the most studied and heavily hunted elk herds in the state has entered the breeding season in recent years with an average 11.5 bulls over 2 years old (per 100 cows) but with only 2.3 bulls > 3 years old. Pregnancy rates have consistently remained above 95% (K. Hamlin, Montana Department of Fish, Wildlife and Parks, personal correspondence). However, to avoid Oregon's experience, Montana has developed hunting-district-specific bull and buck carryover objectives in the Montana elk plan (Youmans 1992) and the Montana deer plan (MFWP 1998), respectively. Officially endorsed by both the U.S. Forest Service and Bureau of Land Management in Montana, the bull carryover objectives outlined in the elk plan are (in theory) cooperatively shared by all land management agencies. In practice, there is quite a bit of variation in how the various agencies work together in meeting these objectives. The Deer Analysis, at this date, lacks any such multi-agency commitment.

Based on the same "interrupted breeding cycle" relationships that resulted in the elk population problems in Oregon, there are some aspects of Montana's hunting season and forest-road-management practices that place deer and elk populations "at risk" for declines in productivity. For example:

1. Youmans (1991) concluded that severe weather contributed to high bull harvest more than most other factors. His results strongly indicated that holding the general hunting season through the Thanksgiving weekend significantly increases bull vulnerability and reduces bull carryover. Consequently, it is concluded that timing of the general season places Montana's deer and elk populations at some risk from a productivity standpoint.
2. While the archery harvest data suggest that a low number of animals are harvested, the level of *unrecovered* elk (Cada 1991) indicated one elk wounded for every elk legally harvested. Specific effects on timing and genetic selection aspects of breeding suggest that the archery season could have adverse effects on elk productivity. Although some of this effect may be mitigated by additional environmental security (e.g., road restrictions) hunting season closures on national forest lands generally take effect October 15 and end December 1. These restrictions do not include the archery season and the potential negative effects of human activity superimposed on the peak period of the elk rut.
3. The general big game season overlaps the peak rut period for deer. An analysis of deer hunting in Montana (MDFWP 1995) points out that large buck availability (and carryover) are at critical stages in some deer herds, and statewide harvest data show large bucks make up a very small percentage of the population. Data also show that buck harvest accelerates during the last week of the season. Therefore, the timing of the general season can place deer populations at risk due to the excessive (or potentially excessive) vulnerability of the few remaining older bucks during the rut.

Ethical Considerations

As we enter the 21st Century, sport-hunting will more often be seen as an anachronism in our modern culture. Even in Montana, where a large proportion of the population participates in hunting, and an even larger proportion regularly consumes game meat, it is difficult to justify hunting as necessary to prevent human starvation. Thus, in Montana as elsewhere, hunters are ". . . a minority; and if we are to continue, we must do it in a way that is acceptable to the majority." (Posewitz 1994:110). As with many other areas of human behavior, legislation is but a partial answer. In the end, ethical behavior by hunters will be determined by education and peer pressure. We include in this review two examples of hunter behavior regarding ungulates that can only be continued to the detriment of all sport-hunting.

Because pronghorns occupy areas without forest cover, hunting poses a special challenge relative to ORV use. Traditional pronghorn hunting involves observing the pronghorn, usually at extremely long distances; and stalking to within 100-250 yards. At this distance, shooting a standing animal usually assures a clean kill. Pronghorn are moderately easy to stalk, and the terrain is normally relatively gentle. Hunters usually derive a high level of satisfaction from this type of hunting experience, and nonhunters would likely view such a hunt as an ethical experience.

Recently, many pronghorn hunters have reported seeing hunters "herding" fleeing pronghorn with ORVs and taking "flock shots" toward running herds at extremely long ranges, often in excess of 500 yards. Such vehicle-oriented hunting has potentially severe consequences for hunting opportunities, including: (1) significant overharvest due to crippling loss, which can only be compensated for by more restrictive regulations; (2) a total breakdown in recreational opportunities for all the pronghorn hunters afield (i.e., if pronghorn herds are being run continuously throughout the daylight hours by ORVs, *nobody* has a reasonable opportunity to pursue or harvest an animal); and (3) a loss in public credibility because such hunting is likely to be viewed as clearly unethical (Posewitz 1994). Although this unethical hunting behavior is already illegal under Montana statutes (87-3-101), it is certainly true that increased enforcement, along with adequate travel planning and ORV restrictions, could help minimize this kind of activity.

There is an existing "trophy" market and buyers who ". . . will pay $10,000 to $35,000 to kill mature 'shooter' bulls behind fences." (Stalling 1998:72). It requires only minutes on the internet to locate facilities offering a "guaranteed kill" of a record bull elk at prices ranging from $4,000 to $15,000 depending on the Boone and Crockett score. Geist (1985:597) observed, "there is danger in allowing wildlife to become a symbol of the rich, making hunting a frivolous pastime of the wealthy . . . . " The killing "trophy" big game animals on game farms is clearly a violation of the "fair chase" ethic (Posewitz 1994). In addition to the obvious ethical problems, Lanka and Guenzel (1991) describe other concerns regarding game farms, including escape, diseases and parasites, hybridization, social and habitat competition, control and enforcement, and impacts of public hunting. Game ranching ". . . will mean the end of elk as we know them through genetic pollution, diseases and competition with uncontrollable feral populations of exotics." (Geist 1991:292).

Posewitz (1994) describes various hunting practices in terms of whether or not they are perceived as being ethical. He labels pursuit of game by vehicle, and hunting of game on game farms as clearly violating the sense of "fair chase." Because of potential impacts on sport-hunting and negative effects on the animals themselves, vehicular pursuit anywhere and the killing of "trophy animals" in game farms should both be prohibited.

Conclusions

The literature on security and buck/bull carryover is generally adequate and shows a strong relationship between adequate security, including the use of restricted vehicle access, and predicted buck and bull carryover. The literature is somewhat less conclusive on the potential for hunting to negatively affect herd productivity as mature males are lost from populations. The literature is even less conclusive in describing relationships for ungulates other than deer and elk, but our interpretation and synthesis is based on an assumption of strong similarity.

Most of the existing literature deals with conventional vehicles using open roads. The effects of ORVs using closed roads/trails or travelling off-road is not well documented. It can be logically inferred however, that ORVs travelling on trails or closed roads are comparable to conventional vehicles using roads. Additionally, it can be inferred that

ORVs travelling in unroaded landscapes, especially when most main ridges are accessible to ORVs, is comparable to conventional vehicles travelling in unrestricted, high road-density situations.

Even though there has been little research reported on ethical behavior in recreational hunting, the generally accepted definitions of “fair chase” and “sportsman” provide clear evidence that there are acceptable standards in the public mind. Pursuit of game animals with vehicles and killing of trophy animals within game farm exclosures are two examples of hunter behavior that exceeds those standards.

Guidelines/Recommendations

Management techniques that reduce the potential for overharvest of ungulates and help promote ethical behavior by hunters during the big game hunting season include the following, by priority:

1. Establish interagency objectives by hunting district and herd unit for deer and elk security that are consistent with state plans for these species.
2. Maintain and improve security through road restrictions and cover management, recognizing that area closures are far more effective that individual road closures.
3. Limit all motorized users (including ORVs) to designated routes.
4. Enforce hunting season restrictions (including the use of such programs as TIP MONT where hunters can report travel violations).
5. Modify hunting regulations where objectives for populations cannot be met through road and cover management alone (for example, restrict the harvest of mature males, restrict hunting pressure during the ruts, or shorten the length of the season).
6. Evaluate and consider road/trail restrictions during the archery season.
7. Develop ORV and vehicle management strategies that prohibit ORV and/or vehicle use in the pursuit of pronghorn antelope.
8. Promote recognition that the ethical lapse represented by “trophy” hunting under game-farm conditions is contrary to the position of professional wildlife managers and the Montana Chapter of The Wildlife Society.

Information Needs

Since any off-road vehicle travel in pursuit of a game animal is already illegal, we hesitate to suggest research in this area. Nevertheless, there is a lack of information concerning the relative disturbance caused by ORV traffic as compared to vehicles on open roads. We also lack an adequate description of the relationship between security cover and hunter density.

LITERATURE CITED

Aasheim, R. 1980. Snowmobile impacts on the natural environment. Pages 191-200 *in* R. N. L. Andrews and P. F. Nowak, editors. Off-road vehicle use: a management challenge. U.S. Department of Agriculture, Office of Environmental Quality, Washington D.C.

Aune, K. E. 1981. Impacts of winter recreationists on wildlife in a portion of Yellowstone National Park, Wyoming. Thesis, Montana State University, Bozeman, Montana. 111pp.

Austin, D. D., R. A. Riggs, P. J. Urness, D. L. Turner, and J. F. Kimball. 1989. Changes in mule deer size in Utah. Great Basin Naturalist 49(1):31-35.

Baldwin, M. F. 1970. The off-road vehicle and environmental quality. Conservation Foundation, Washington D.C. 52pp.

Bansner, U. 1976. Mountain goat-human interactions in the Sperry-Gunsight Pass area, Glacier National Park. University of Montana, Missoula, Montana. Unpublished report. 46pp.

Basile, J. V., and T. N. Lonner. 1979. Vehicle restrictions influence elk and hunter distribution in Montana. Journal of Forestry 77(3):155-159.

Beall, R. C. 1974. Winter habitat selection and use by a western Montana elk herd. Dissertation, University of Montana, Missoula, Montana. 197pp.

Bear, G. D., and G. W. Jones. 1973. History and distribution of bighorn sheep in Colorado. Colorado Division of Wildlife, Denver, Colorado. 232pp.

Berwick, S. H. 1968. Observations on the decline of the Rock Creek, Montana, population of bighorn sheep. Thesis, University of Montana, Missoula, Montana. 245pp.

Bleich, V. C., R. T. Bowyer, A. W. Pauli, M. C. Nicholson, and R. W. Anthes. 1994. Mountain sheep *Ovis canadensis* and helicopter surveys: ramifications for the conservation of large mammals. Biological Conservation 70(1):1-7.

Bollinger, J. G., O. J. Rongstad, A. Soom, and T. Larson. 1972. Snowmobile noise effects on wildlife. Final Report. Engineering Experiment Station, University of Wisconsin, Madison, Wisconsin.

Brooks, R. 1988. The net economic value of deer hunting in Montana. Montana Department of Fish, Wildlife and Parks, Helena, Montana. 32pp.

Bruns, E. H. 1977. Winter behavior of pronghorns in relation to habitat. Journal of Wildlife Management 41(3):560-571.

Bubenik, A. B. 1982. Physiology. Pages 125-179 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America. Stackpole Books, Harrisburg, Pennsylvania. 698pp.

Bullock, D. J., F. J. Kerridge, A. Hanlon, and R. W. Arnold. 1993. Short term responses of deer to recreational disturbances in two deer parks. Journal of Zoology (London) 230(2):327-332.

Bunch, T. D., and G. W. Workman. 1993. Sonic boom/animal stress project report on elk, antelope, and Rocky Mountain bighorn sheep. Journal of the Acoustical Society of America 4:2378.

Burcham, M. G., W. D. Edge, L. J. Lyon, C. L. Marcum, and K. T. Weber. 1998. Final report of the Chamberlain Creek elk studies, 1977-1983 and 1993-1996. School of Forestry, University of Montana, Missoula, Montana. 260pp.

Cada, J. D. 1991. Preferences and attitudes of Montana archery hunters. Pages 199-203 *in* A. G. Christensen, L. J. Lyon, and T. N. Lonner, compilers. Proceedings of the elk vulnerability symposium. Montana State University, Bozeman, Montana.

Canfield, J. E. 1984. Elk habitat use and the impact of the construction and energization of a 500kV powerline on the North Boulder winter range, Montana. Thesis, Montana State University, Bozeman, Montana. 130pp.

Carl, G. R., and C. T. Robbins. 1988. The energetic cost of predator avoidance in neonatal ungulates: hiding versus following. Canadian Journal of Zoology 66(1):239-246.

Cassirer, E. F., D. J. Freddy, and E. D. Ables. 1992. Elk responses to disturbance by cross-country skiers in Yellowstone National Park. Wildlife Society Bulletin 20(4):375-381.

Chabot, D. 1991. The use of heart rate telemetry in assessing the metabolic cost of disturbances. Transactions of the North American Wildlife and Natural Resources Conference 56:256-263.

Chappel, R. W., and R. J. Hudson. 1978. Winter bioenergetics of Rocky Mountain bighorn sheep. Canadian Journal of Zoology 56(11):2388-2393.

Chappel, R. W., and R. J. Hudson. 1980. Prediction of energy expenditures by Rocky Mountain bighorn sheep. Canadian Journal of Zoology 58(10):1908-1912.

Chester, J. M. 1976. Human wildlife interactions in the Gallatin Range, Yellowstone National Park, 1973-1974. Thesis, Montana State University, Bozeman, Montana. 114pp.
Clutton-Brock, T. H., M. Major, and F. E. Guinness. 1985. Population regulation in male and female red deer. Journal of Animal Ecology 54:831-846.
Coggins, V. 1976. Controlled vehicle access during elk season in the Chesnimnus area, Oregon. Pages 58-61 *in* S. R. Hieb, editor. Proceedings of the elk-logging-roads symposium. Forestry Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho.
Cook, J. G., L. L. Irwin, L. D. Bryant, R. A. Riggs, and J. W. Thomas. 1998. Relations of forest cover and condition of elk: a test of the thermal cover hypothesis in summer and winter. Wildlife Monographs 141. 61pp.
Cook, J. G., L. J. Quinlan, L. L. Irwin, L. D. Bryant, R. A. Riggs, and J. W. Thomas. 1996. Nutrition-growth relations of elk calves during late summer and fall. Journal of Wildlife Management 60(3):528-541.
Côté, S. D. 1996. Mountain goat responses to helicopter disturbance. Wildlife Society Bulletin 24(4):681-685.
DeForge, J. R. 1976. Stress: Is it limiting bighorns? Transactions of the Desert Bighorn Council 20:30-31.
DeMarchi, R. 1975. Report and recommendations of the workshop on California bighorn sheep. Pages 143-163 *in* J. B. Trefethen, editor. The wild sheep in modern North America. Boone and Crockett Club and Winchester Press, New York, New York.
Denniston, R. H. 1956. Ecology, behavior and population dynamics of the Wyoming or Rocky Mountain moose, *Alces alces shirasi*. Zoologica 41:105-118.
Dorrance, M. J., P. J. Savage, and D. E. Huff. 1975. Effects of snowmobiles on white-tailed deer. Journal of Wildlife Management 39(3):563-569.
Douglas, C. L. 1976. Coordination of bighorn research and management in Joshua Tree National Monument. Transactions of the North American Wild Sheep Conference 2:1-15.
Doyle, M. B. 1980. Progress in ORV planning and management of USDA managed lands: snowmobile user's perspective. Pages 183-187 *in* R. N. L. Andrews and P. F. Nowak, editors. Off-road vehicle use: a management challenge. U.S. Department of Agriculture, Office of Environmental Quality, Washington D.C.
Duffield, J., and J. Holliman. 1988. The net economic value of elk hunting in Montana. Report to Montana Department of Fish, Wildlife and Parks. University of Montana, Missoula, Montana. 53pp.
Dunaway, D. J. 1971. Human disturbance as a limiting factor of Sierra Nevada bighorn sheep. Transactions of the North American Wild Sheep Conference 1:165-173.
Eckstein, R. G., T. F. O'Brien, O. J. Rongstad, and J. G. Bollinger. 1979. Snowmobile effects on movement of white-tailed deer: a case study. Environmental Conservation 6(1):45-51.
Eckstein, R. G., and O. J. Rongstad. 1973. Effects of snowmobiles on the movements of white-tailed deer in northern Wisconsin. Proceedings of the Midwest Fish and Wildlife Conference 35:39-40.
Edge, W. D. 1982. Distribution, habitat use and movements of elk in relation to roads and human disturbance in western Montana. Thesis, University of Montana, Missoula, Montana.
Edge, W. D., and C. L. Marcum. 1985. Movements of elk in relation to logging disturbances. Journal of Wildlife Management 49(4):926-930.
Edge, W. D., and C. L. Marcum 1991. Topography ameliorates the effects of roads and human disturbance on elk. Pages 132-137 *in* A. G. Christensen, L. J. Lyon, and T. N. Lonner, compilers. Proceedings of the elk vulnerability symposium. Montana State University, Bozeman, Montana.
Edge, W. D., C. L. Marcum, and S. L. Olson-Edge. 1987. Summer habitat selection by elk in western Montana: a multivariate approach. Journal of Wildlife Management 51(4):844-851.
Elder, J. M. 1977. Human interactions with Sierra Nevada bighorn sheep in the Mount Baxter herd. Thesis, University of Michigan, Ann Arbor, Michigan. 93pp.
Espmark, Y., and R. Langvatn. 1985. Development and habituation of cardiac and behavioral responses in young red deer calves (*Cervus elaphus*) exposed to alarm stimuli. Journal of Mammalogy 66:702-711.
Fancy, S. G., and R. G. White. 1985. Energy expenditures by caribou while cratering in snow. Journal of Wildlife Management 49(4):987-993.
Ferguson, M. A. D., and L. B. Keith. 1982. Influence of Nordic skiing on distribution of moose and elk in Elk Island National Park, Alberta. Canadian Field-Naturalist 96(1):69-78.
Ferris, R. M., and M. J. Kutilek. 1989. Responses of black-tailed deer to off-highway vehicles in Hollister Hills State Vehicular Recreation Area Hollister, CA. San Jose State University, Department of Biological Sciences, San Jose, California. 42pp.

Flook, D. R. 1970. Causes and implications of an observed sex differential in the survival of wapiti. Report Series - Number 11. Canadian Wildlife Service, Ottawa, Canada. 71pp.
Floyd, J. P. 1987. Heart rate as an indicator of oxygen consumption during auditory and visual stimulation of caribou (*Rangifer tarandus*). Thesis, University of Alaska, Fairbanks, Alaska. 68pp.
Foster, B. R., and E. Y. Rahs. 1985. A study of canyon-dwelling mountain goats in relation to proposed hydroelectric development in northwest British Columbia, Canada. Biological Conservation 33:209-228.
Freddy, D. J. 1977. Deer-elk investigations: snowmobile harassment of mule deer on cold winter ranges. Colorado Division of Wildlife Project W-38-R-32/WP14/J11. 15pp.
Freddy, D. J. 1984*a*. Heart rates for activities of mule deer at pasture. Journal of Wildlife Management 48(3):962-969.
Freddy, D. J. 1984*b*. Quantifying capacity of winter ranges to support deer -- evaluation of thermal cover used by deer. Pages 21-25 *in* Wildlife Research Report. Colorado Division of Wildlife, Denver, Colorado.
Freddy, D. J. 1985. Quantifying capacity of winter ranges to support deer -- evaluation of thermal cover used by deer. Pages 13-36 *in* Wildlife Research Report. Colorado Division of Wildlife, Denver, Colorado.
Freddy, D. J. 1986*a*. Responses of adult mule deer to human harassment during winter. Page 286 *in* R. D. Comer, T. G. Baumann, P. Davis, J. W. Monarch, J. Todd, S. VanGytenbeek, D. Wills, and J. Woodling, editors. Proceedings II. Issues and technology in the management of impacted western wildlife. Thorne Ecological Institute, Boulder, Colorado.
Freddy, D. J. 1986*b*. Quantifying capacity of winter ranges to support deer -- evaluation of thermal cover used by deer. Pages 9-18 *in* Wildlife Research Report. Colorado Division of Wildlife, Denver, Colorado.
Freddy, D. J., W. M. Bronaugh, and M. C. Fowler. 1986. Responses of mule deer to disturbance by persons afoot and snowmobiles. Wildlife Society Bulletin 14(1):63-68.
Gates, C. C., and R. J. Hudson. 1979. Effects of posture and activity on metabolic responses of wapiti to cold. Journal of Wildlife Management 43(2):564-567.
Geist, V. 1971. Bighorn sheep ecology. Wildlife Society News 136:61.
Geist, V. 1978. Behavior. Pages 283-296 *in* J. L. Schmidt and D. L. Gilbert, editors. Big game of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania. 494pp.
Geist, V. 1982. Behavior. Pages 219-277 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America. Stackpole Books, Harrisburg, Pennsylvania. 698pp.
Geist, V. 1985. Game ranching: threat to wildlife conservation in North America. Wildlife Society Bulletin 13(4):594-598.
Geist, V. 1991. Game-ranching: menace to the survival of the North American elk. Pages 292-295 *in* A. G. Christensen, L. J. Lyon, and T. N. Lonner, compilers. Proceedings of the elk vulnerability symposium. Montana State University, Bozeman, Montana.
Geist, V., and R. G. Petocz. 1977. Bighorn sheep in winter: do rams maximize reproductive fitness by spatial and habitat segregation from ewes? Canadian Journal of Zoology 55(11):1802-1810.
Geist, V., R. E. Stemp, and R. H. Johnson 1985. Heart-rate telemetry of bighorn sheep as a means to investigate disturbances. Pages 92-99 *in* N. G. Bayfield and G. C. Barrow, editors. The ecological impacts of outdoor recreation on mountain areas in Europe and North America. Recreation Ecology Research Group, Wye, Ashford, Kent, UK. 203
Gerstell, R. 1937. Winter deer losses. Pennsylvania Game News 8(7):18-21.
Gilbert, F. F., and M. C. Bateman. 1983. Some effects of winter shelter conditions on while-tailed deer, *Odocoileus virginianus*. Canadian Field Naturalist 97:391-400.
Goodson, N. J. 1978. Status of bighorn sheep in Rocky Mountain National Park. Thesis, Colorado State University, Fort Collins, Colorado. 190pp.
Goodson, N. J., D. R. Stevens, and J. A. Bailey. 1991. Effects of snow on foraging ecology and nutrition of bighorn sheep. Journal of Wildlife Management 55(2):214-222.
Graham, H. 1971. Environmental analysis procedures for bighorn in the San Gabriel Mountains. Transactions of the Desert Bighorn Council 15:38-45.
Graham, H. 1980. The impact of modern man. Pages 288-309 *in* G. Monson and L. Sumner, editors. The desert bighorn: it's life history, ecology and management. University of Arizona Press, Tucson, Arizona.
Hamilton, K. S., S. A. Holl, and C. L. Douglas. 1982. An evaluation of the effects of recreational activity on bighorn sheep in the San Gabriel Mountains, CA. Transactions of the Desert Bighorn Council 26:50-55.
Hansen, M. C. 1982. Desert bighorn sheep: another view. Wildlife Society Bulletin 10(2):133-140.
Harris, L. K., P. R. Krausman, and W. W. Shaw. 1995. Human attitudes and mountain sheep in a wilderness setting. Wildlife Society Bulletin 23(1):66-72.

Hayes, C. L., P. R. Krausman, and M. C. Wallace. 1994. Habitat, visibility, heart rate and vigilance of bighorn sheep. Transactions of the Desert Bighorn Council 38:6-11.

Herbold, H., F. Suchentruck, S. Wagner, and R. Willing. 1992. The influence of anthropogenic disturbances on the heart frequency of red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*). Z. Jagdwiss 38(3):145-159 [In German with English summary].

Hicks, L. L., and J. M. Elder. 1979. Human disturbance of Sierra Nevada bighorn sheep. Journal of Wildlife Management 43(4):909-915.

Hillis, J. M., M. J. Thompson, J. E. Canfield, L. J. Lyon, C. L. Marcum, P. M. Dolan, and D. W. MCleerey 1991. Defining elk security: the Hillis paradigm. Pages 38-43 *in* A. G. Christensen, L. J. Lyon, and T. N. Lonner, compilers. Proceedings of the elk vulnerability symposium. Montana State University, Bozeman, Montana.

Hines, W. W., J. C. Lemos, and N. A. Hartmann Jr. 1985. Male breeding efficiency in Roosevelt elk of southwestern Oregon. Wildlife Research Report No. 15. Oregon Department of Fish and Wildlife. 25pp.

Horejsi, B. L. 1976. Some thoughts on harassment and bighorn sheep. Pages 149-155 *in* E. T. Thorne, editor. Proceedings of the biennial symposium of the Northern Wild Sheep Council. Jackson, Wyoming. 165pp.

Horejsi, B. L. 1986. Bighorn sheep, Mount Allan and the 1988 Winter Olympics: political and biological realities. Pages 313-324 *in* G. Joslin, editor. Proceedings of the Fifth Northern Wild Sheep and Goat Council. Missoula Montana. Montana Department of Fish, Wildlife and Parks.

Hoskinson, R. L., and J. R. Tester. 1980. Migration behavior of pronghorn in southeastern Idaho. Journal of Wildlife Management 44(1):132-144.

Houston, D. B. 1982. The northern Yellowstone elk. MacMillan, New York, New York. 474pp.

Huff, D. E., and P. J. Savage. 1972. A correlation of deer movements with snowmobile activity in Minnesota during winter. Proceedings of the Midwest Fish and Wildlife Conference 34:42-49.

Hurley, M. A. 1994. Summer-fall ecology of the Blackfoot-Clearwater elk herd of western Montana. Thesis, University of Idaho, Moscow, Idaho. 138pp.

Irwin, L. L., and J. M. Peek. 1979. Relationship between road closure and elk behavior in northern Idaho. Pages 199-205 *in* M. S. Boyce and L. D. Hayden-Wing, editors. North American elk: ecology, behavior and management. University of Wyoming, Laramie, Wyoming.

Joslin, G. 1986. Mountain goat population changes in relation to energy exploration along Montana's Rocky Mountain Front. Pages 253-271 *in* G. Joslin, editor. Proceedings of the Fifth Northern Wild Sheep and Goat Council.

King, M. M. 1985. Behavioral response of desert bighorn sheep to human harassment: a comparison of disturbed and undisturbed populations. Dissertation, Utah State University, Logan, Utah. 135pp.

King, M. M., and G. W. Workman. 1986. Response of desert bighorn sheep to human harassment: management implications. Transactions of the North American Wildlife and Natural Resources Conference 51:74-85.

Knight, R. L., and D. N. Cole. 1995. Factors that influence wildlife responses to recreationists. Pages 71-79 *in* R. L. Knight and H. K. Cordell, editors. Wildlife and recreation: coexistence through management and research. Island Press, Washington D.C.

Kopischke, E. D. 1972. Effects of snowmobile activity on the distribution of white-tailed deer in south-central Minnesota, 1971-1972. Minnesota Game Research Quarterly Progress Reports 32(3):139-146.

Krausman, P. R., and B. D. Leopold. 1986. The importance of small populations of desert bighorn sheep. Transactions of the North American Wildlife and Natural Resources Conference 51:52-61.

Kuck, L. 1986. The impacts of phosphate mining on big game in Idaho: a cooperative approach to conflict resolution. Transactions of the North American Wildlife and Natural Resources Conference 51:90-97.

Lanka, R. P., and R. J. Guenzel 1991. Game farms: what are the implications for North American elk? Pages 285-291 *in* A. G. Christensen, L. J. Lyon, and T. N. Lonner, compilers. Proceedings of the elk vulnerability symposium. Montana State University, Bozeman, Montana.

Lavigne, G. R. 1976. Winter response of deer to snowmobiles and selected natural factors. Thesis, University of Maine, Orono, Maine. 68pp.

Leckenby, D., C. Wheaton, and L. Bright 1991. Elk vulnerability - the Oregon situation. Pages 89-98 *in* A. G. Christensen, L. J. Lyon, and T. N. Lonner, compilers. Proceedings of the elk vulnerability symposium. Montana State University, Bozeman, Montana.

Leege, T. A. 1984. Guidelines for evaluating and managing summer elk habitat in northern Idaho. Wildlife Bulletin No. 11. Idaho Department of Fish and Game, Boise, Idaho. 35pp.

Leege, T. A., and W. O. Hickey. 1977. Elk-snow-habitat relationships in the Pete King Drainage, Idaho. Wildlife Bulletin No. 6. Idaho Department of Fish and Game, Boise, Idaho. 23pp.

Leopold, A. 1933. Game management. Charles Scribner's Sons, New York, New York. 481pp.
Leptich, D. J., and P. Zager 1991. Road access management effects on elk mortality and population dynamics. Pages 126-131 *in* A. G. Christensen, L. J. Lyon, and T. N. Lonner, compilers. Proceedings of the elk vulnerability symposium. Montana State University, Bozeman, Montana.
LeResche, R. H. 1966. Behavior and calf survival in Alaska moose. Thesis, University of Alaska, Fairbanks, Alaska. 83pp.
Leslie, D. M., Jr., and C. L. Douglas. 1980. Human disturbance at water sources of desert bighorn sheep. Wildlife Society Bulletin 8(4):284-290.
Lieb, J. W. 1981. Activity, heart rate, and associated energy expenditure of elk in western Montana. Dissertation, University of Montana, Missoula, Montana. 239pp.
Lieb, J. W., and A. S. Mossman. 1966. Final progress report on Roosevelt elk in Prairie Creek Redwoods State Park. California Department of Parks and Recreation. Interagency Agreement 4-050094-025. 8pp.
Lonner, T. N., and J. D. Cada 1982. Some effects of forest management on elk hunting opportunity. Pages 119-128 *in* T. L. Britt and D. P. Theobald, editors. Proceedings of the western states elk workshop. 22-24 February 1982, Flagstaff, Arizona. Arizona Fish and Game Department, Phoenix, Arizona.
Loomis, J., and J. Cooper. 1988. The net economic value of antelope hunting in Montana. University of California, Davis, California. Report to Montana Department of Fish, Wildlife and Parks. 26pp.
Luz, G. A., and J. B. Smith. 1976. Reactions of pronghorn antelope to helicopter overflight. Acoustical Society of America 59(6):1514-1515.
Lyon, L. J. 1979*a*. Habitat effectiveness for elk as influenced by roads and cover. Journal of Forestry 77:658-660.
Lyon, L. J. 1979*b*. Influences of logging and weather on elk distribution in western Montana. Research Paper INT-RP-236. U.S. Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah. 11pp.
Lyon, L. J. 1983. Road density models describing habitat effectiveness for elk. Journal of Forestry 81(9):592-595 + 613.
Lyon, L. J., and J. E. Canfield 1991. Habitat selections by Rocky Mountain elk under hunting season stress. Pages 99-105 *in* A. G. Christensen, L. J. Lyon, and T. N. Lonner, Compilers. Proceedings of the elk vulnerability symposium. Montana State University, Bozeman, Montana.
Lyon, L. J., and A. G. Christensen. 1992. A partial glossary of elk management terms. General Technical Report INT-GTR-288. U.S. Forest Service, Intermountain Research Station, Ogden, Utah. 6pp.
Lyon, L. J., and A. L. Ward. 1982. Elk and land management. Pages 443-477 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America. Stackpole Books, Harrisburg, Pennsylvania. 698pp.
Mac Arthur, R. A., R. H. Johnston, and V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to the study of wildlife harassment. University of Calgary, Calgary, Alberta, Canada. Unpublished report. 31pp.
MacArthur, R. A., and V. Geist. 1986. Cardiac response of bighorn sheep to trapping and radio instrumentation. Canadian Journal of Zoology 64(5):1197-1200.
MacArthur, R. A., V. Geist, and R. H. Johnston. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. Journal of Wildlife Management 46(2):351-358.
Mackie, R. J., D. E. Pac, K. L. Hamlin, and G. L. Dusek. 1998. Ecology and management of mule deer and white-tailed deer in Montana. Montana Fish, Wildlife and Parks, Wildlife Division, Helena, Montana. 180pp.
Malaher, G. W. 1967. Improper use of snow vehicles for hunting. Transactions of the North American Wildlife and Natural Resources Conference 32:429-433.
Marcum, C. L. 1976. Habitat selection and use during summer and fall months by a western Montana elk herd. Pages 91-96 *in* S. R. Hieb, editor. Proceedings of the elk-logging-roads symposium. Forestry Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho.
Marcum, C. L., and W. D. Edge 1991. Sexual differences in distribution of elk relative to roads and logged areas in western Montana. Pages 142-148 *in* A. G. Christensen, L. J. Lyon, and T. N. Lonner, compilers. Proceedings of the elk vulnerability symposium. Montana State University, Bozeman, Montana.
Martinka, C. J. 1967. Mortality of northern Montana pronghorns in a severe winter. Journal of Wildlife Management 31(1):159-164.
Mautz, W. W. 1978. Sledding on a bushy hillside: the fat cycle in deer. Wildlife Society Bulletin 6(2):88-90.
McEwan, E. H., and P. E. Whitehead. 1970. Seasonal changes in the energy and nitrogen intake in reindeer and caribou. Canadian Journal of Zoology 48(5):905-913.
McLaren, M. A., and J. E. Green. 1985. The reactions of muskoxen to snowmobile harassment. Arctic 38(3):188-193.

McMillan, J. F. 1954. Some observations on moose in Yellowstone Park. American Midland Naturalist 52(2):392-399.

Merrill, A., and J. Jacobson. 1997. Montana Almanac. Falcon Press, Helena, Montana. 491pp.

Miller, G., and E. L. Smith. 1985. Human activity in desert bighorn sheep: what disturbs sheep? Transactions of the Desert Bighorn Sheep Council 29:4-7.

Moen, A. N. 1976. Energy conservation by white-tailed deer in the winter. Ecology 57:192-198.

Moen, A. N. 1978. Seasonal changes in heart rates, activity, metabolism, and forage intake of white-tailed deer. Journal of Wildlife Management 42(4):715-738.

Moen, A. N., S. Whittemore, and B. Buxton. 1982. Effects of disturbance by snowmobiles on heart rate of captive white-tailed deer. New York Fish and Game Journal 29(2):176-183.

Montana Department of Fish, Wildlife and Parks. 1995. Montana deer & deer hunting: a management analysis. Montana Department of Fish, Wildlife and Parks, Wildlife Division, Helena, Montana. 55pp.

Montana Fish, Wildlife and Parks. 1998. Deer population objectives and hunting regulation strategies. Fish, Wildlife and Parks Commission, Helena, Montana. 58pp.

Montana Fish, Wildlife and Parks. 1999. Final programmatic environmental impact statement. Record of decision and executive summary. Montana Fish, Wildlife and Parks, Helena, Montana. 46pp.

Morgantini, L. E., and R. J. Hudson 1979. Human disturbance and habitat selection in elk. Pages 132-139 *in* M. S. Boyce and L. D. Hayden-Wing, editors. North American elk: ecology, behavior and management. Proceedings of a symposium on elk ecology and management. University of Wyoming, Laramie, Wyoming.

Morrison, J. A., C. E. Trainer, and P. L. Wright. 1959. Breeding season in elk as determined from known-age embryos. Journal of Wildlife Management 23(1):27-34.

Morrison, J. R., W. J. De Vergie, and A. W. Alldredge 1991. The effects of ski area development on geographic use patterns of elk. Page 60 *in* R. D. Comer, P. R. Davis, S. Q. Foster, C. V. Grant, S. Rush, O. I. Thorne, and J. Todd, editors. Issues and technology in the management of impacted wildlife. Proceedings of a national symposium. Thorne Ecological Institute, Boulder, Colorado.

Morrison, J. R., W. J. De Vergie, A. W. Alldredge, A. E. Byrne, and W. W. Andree. 1995. The effects of ski area expansion on elk. Wildlife Society Bulletin 23(3):481-489.

Nelson, J. R., and T. A. Leege. 1982. Nutritional requirements and food habits. Pages 323-367 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America. Stackpole Books, Harrisburg, Pennsylvania. 698pp.

Neumann P. W., Merriam H. G. 1972. Ecological effects of snowmobiles. The Canadian Field-Naturalist 86:207-12.

Nilssen, K. J., H. K. Johnsen, A. Rognmo, and A. S. Blix. 1984. Heart rate and energy expenditure in resting and running Svalbard and Norwegian reindeer. American Journal of Physiology 246:R963-R967.

Noyes, J. H., B. K. Johnson, L. D. Bright, S. L. Findholt, and J. W. Thomas. 1996. Effects of bull age on conception dates and pregnancy rates of cow elk. Journal of Wildlife Management 60(3):508-517.

Parker, K. L., M. P. Gillingham, T. A. Hanley, and C. T. Robbins. 1999. Energy and protein balance of free-ranging black-tailed deer in a natural forest environment. Wildlife Monographs 143.

Parker, K. L., C. T. Robbins, and T. A. Hanley. 1984. Energy expenditures for locomotion by mule deer and elk. Journal of Wildlife Management 48(2):474-488.

Perry, C., and R. Overly 1976. Impact of roads on big game distribution in portions of the Blue Mountains of Washington. Pages 62-68 *in* S. R. Hieb, editor. Proceedings of the elk-logging-roads symposium. Forestry Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho.

Phillips, G. E. 1998. Effects of human-induced disturbance during calving season on reproductive success of elk in the upper Eagle River Valley. Dissertation, Colorado State University, Fort Collins, Colorado. 101pp.

Posewitz, J. 1994. Beyond fair chase: the ethic and tradition of hunting. Falcon Publishing, Helena, Montana. 118pp.

Price, S., and R. Sibly. 1993. Heart-rate of red deer during routine handling procedures taking account of motor activity and basal metabolic rate. Applied Animal Behavior Science 35(3):297.

Regelin, W. L., C. C. Schwartz, and A. W. Franzmann. 1985. Seasonal energy metabolism of adult moose. Journal of Wildlife Management 49(2):388-393.

Renecker, L. A., and R. J. Hudson. 1986. Seasonal energy expenditures and thermoregulatory responses of moose. Canadian Journal of Zoology 64(2):322-327.

Richens, V. B., and G. R. Lavigne. 1978. Response of white-tailed deer to snowmobiles and snowmobile trails in Maine. Canadian Field-Naturalist 92:334-344.

Robinson, W. L. 1960. Test of shelter requirement of penned white-tailed deer. Journal of Wildlife Management 24:364-371.

Rognrud, M., and R. Janson. 1971. Elk. Pages 39-51 *in* T. W. Mussehl and F. W. Howell, editors. Game management in Montana. Montana Fish and Game Department, Helena, Montana. 238pp.
Rost, G. R. 1975. Response of deer and elk to roads. Thesis, Colorado State University, Fort Collins, Colorado. 51pp.
Rost, G. R., and J. A. Bailey. 1974. Responses of deer and elk to roads on the Roosevelt National Forest. Department of Fish and Wildlife Biology, Colorado State University, Fort Collins, Colorado. 19pp.
Rost, G. R., and J. A. Bailey. 1979. Distribution of mule deer and elk in relation to roads. Journal of Wildlife Management 43(3):634-641.
Rudd, W. J., A. L. Ward, and L. L. Irwin. 1983. Do split hunting seasons influence elk migrations from Yellowstone National Park? Wildlife Society Bulletin 11(4):328-331.
Russell, D. E., K. L. Gerhart, R. G. White, and D. Van de Wetering. 1998. Detection of early pregnancy in caribou: evidence for embryonic mortality. Journal of Wildlife Management 62(3):1066-1075.
Ryder, T. J., and L. L. Irwin. 1987. Winter habitat relationships of pronghorns in southcentral Wyoming. Journal of Wildlife Management 51(1):79-85.
Schultz, R. D., and J. A. Bailey. 1978. Responses of national park elk to human activity. Journal of Wildlife Management 42(1):91-100.
Segerstrom, T. 1982. Effects of an operational coal strip mine on pronghorn antelope. Pages 174-208 *in* J. V. McKenzie, chair. Proceedings of the tenth pronghorn antelope workshop.
Severinghaus, C. W., and B. F. Tullar. 1975. Wintering deer versus snowmobiles. Conservationist 29(6):31.
Shoesmith, M. W., and W. H. Koonz. 1977. The maintenance of an urban deer herd in Winnipeg, Manitoba . Transactions of the North American Wildlife and Natural Resources Conference 42:278-285.
Silver, H., N. F. Colovos, J. B. Holter, and H. H. Hayes. 1969. Fasting metabolism of white-tailed deer. Journal of Wildlife Management 33(3):490-498.
Singer, F. J., A. T. Harting, and K. K. Symonds. 1997. Density-dependence, compensation, and environmental effects on elk calf mortality in Yellowstone National Park. Journal of Wildlife Management 61(1):12-25.
Skiba, G. T. 1981. Ecological evaluation of the Dinosaur National Monument bighorn sheep herd. Thesis, Colorado State University, Fort Collins, Colorado. 107pp.
Skovlin, J. M. 1982. Habitat requirements and evaluations. Pages 369-413 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America. Stackpole Books, Harrisburg, Pennsylvania. 698pp.
Smith, B. L., and S. H. Anderson. 1998. Juvenile survival and population regulation of the Jackson Elk Herd. Journal of Wildlife Management 62(3):1036-1045.
Smith, J. L. 1980. Reproductive rates, age structure and management of Roosevelt elk in Washington's Olympic Mountains. Pages 67-111 in W. Macgregor, editor. Proceedings of the western states elk workshop. 27-28 February 1980, Cranbrook, British Columbia. British Columbia Ministry of Environment, Fish and Wildlife Branch.
Stalling, D. 1998. The perils of elk farms. Bugle 15(4):70-75.
Stemp, R. E. 1983. Heart rate responses of bighorn sheep to environmental factors and harassment. Thesis, University of Calgary, Alberta, Canada. 314pp. + appendices.
Stevens, D. R. 1982. Bighorn sheep management in Rocky Mountain National Park. Pages 244-253 *in* J. A. Bailey and G.G. Schoonveld, editors. Proceedings of the third biennial symposium of the Northern Wild Sheep and Goat Council. Colorado Division of Wildlife and Colorado State University Department of Fishery and Wildlife Biology, Fort Collins, Colorado.
Stockwell, C. A., G. C. Bateman, and J. Berger. 1991. Conflicts in national parks: a case study of helicopters and bighorn sheep time budgets at the Grand Canyon. Biological Conservation 56(3):317-328.
Sweeney, J. M., and J. R. Sweeney. 1984. Snow depths influencing winter movements of elk. Journal of Mammalogy 65(3):524-526.
Telfer, E. S. 1978. Cervid distribution, browse and snow cover in Alberta. Journal of Wildlife Management 42(2):352-361.
Tevis, L. Jr. 1959. Man's effect on bighorn in the San Jacinto-Santa Rosa Mountains. Transactions of the Desert Bighorn Council 3:69-76.
Thiessen, J. L. 1976. Some relations of elk to logging, roading, and hunting in Idaho's Game Management Unit 39. Pages 3-5 *in* S. R. Hieb, editor. Proceedings of the elk-logging-roads symposium. Forestry Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho.
Thompson, M. J. 1981. Mountain goat distribution, population characteristics and habitat use in the Sawtooth Range, Montana. Thesis, Montana State University, Bozeman, Montana. 80pp.

Thompson, M. J., and R. E. Henderson. 1998. Elk habituation as a credibility challenge for wildlife professionals. Wildlife Society Bulletin 26(3):477-483.

Thorne, E. T., R. E. Dean, and W. G. Hepworth. 1976. Nutrition during gestation in relation to successful reproduction in elk. Journal of Wildlife Management 40(2):330-335.

Thorne, T., G. Butler, T. Varcalli, K. Becker, and S. Hayden-Wing. 1979 The status, mortality, and response to management of the bighorn sheep of Whiskey Mountain. Game and Fish Research Lab Wildlife Technical Report 7. Wyoming Game and Fish Department, Cheyenne, Wyoming. 213 pp.

Unsworth, J. W. 1993. Elk mortality, habitat use, and home range in the clearwater drainage of north-central Idaho (*Cervus elaphus*). Dissertation, University of Idaho, Moscow, Idaho.

Unsworth, J. W., and L. Kuck 1991. Bull elk vulnerability in the Clearwater Drainage of north-central Idaho. Pages 85-88 *in* A. G. Christensen, L. J. Lyon, and T. N. Lonner, compilers. Proceedings of the elk vulnerability symposium. Montana State University, Bozeman, Montana.

Verme, L. J. 1965. Reproduction studies on penned white-tailed deer. Journal of Wildlife Management 29(1):74-79.

Verme, L. J. 1967. Influence of experimental diets on white-tailed deer reproduction. Transactions of the North American Wildlife and Natural Resources Conference 32:302-419.

Vogel, W. 1983. The effects of housing developments and agriculture on the ecology of white-tailed deer and mule deer in the Gallatin Valley, Montana. Thesis, Montana State University, Bozeman, Montana. 100pp.

Wallmo, O. C., L. H. Carpenter, R. Regelin, B. Gill, and D. L. Baker. 1977. Evaluation of deer habitat on a nutritional basis. Journal of Range Management 30(2):122-127.

Ward, A. L. 1976. Elk behavior in relation to timber harvest operations and traffic on the Medicine Bow Range in south-central Wyoming. Pages 32-43 *in* S. R. Hieb, editor. Proceedings of the elk-logging-roads symposium. Forestry Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho.

Ward, A. L., and J. J. Cupal 1979. Telemetered heart rate of three elk as affected by activity and human disturbance. Pages 47-56 *in* K. Downing, editor. Symposium on dispersed recreation and natural resource management. Utah State University, College of Natural Resources, Logan, Utah.

Ward, A. L., J. J. Cupal, A. L. Lea, C. A. Oakley, and R. W. Weeks. 1973. Elk behavior in relation to cattle grazing, forest recreation, and traffic. Transactions of the North American Wildlife and Natural Resources Conference 38:327-337.

Weber, K. T. 1996. Identifying landscape elements in relation to elk kill sites in western Montana. Thesis, University Montana, Missoula, Montana.

Wehausen, J. D., L. L. Hicks, D. P. Garber, and J. Elder. 1977. Bighorn sheep management in the Sierra Nevada. Transactions of the Desert Bighorn Council 21:30-32.

Weiner, J. 1977. Energy metabolism of the roe deer. Acta Theriologica 22:3-24.

Weisenberger, M. E., P. R. Krausman, M. C. Wallace, D. W. De Young, and O. E. Maughan. 1996. Effects of simulated jet aircraft noise on heart rate and behavior of desert ungulates. Journal of Wildlife Management 60(1):52-61.

Wesley, D. E., K. L. Knox, and J. G. Nagy. 1973. Energy metabolism of pronghorn antelopes. Journal of Wildlife Management 37:563-573.

Wickstrom, M. L., C. T. Robbins, T. A. Hanley, D. E. Spalinger, and S. M. Parish. 1984. Food intake and foraging energetics of elk and mule deer. Journal of Wildlife Management 48(4):1285-1301.

Wilson, L. O. 1969. The forgotten desert bighorn habitat requirement. Transactions of the Desert Bighorn Council 13:108-113.

Wilson, L. O. 1975. Report and recommendations of the desert and Mexican bighorn sheep workshop group. Pages 110-143 *in* J. B. Trefethen, editor. The wild sheep in modern North America. Boone and Crockett Club and Winchester Press, New York, New York.

Wood, A. K. 1988. Use of shelter by mule deer during winter. Prairie Naturalist 20:15-22.

Yarmoloy, C., M. Bayer, and V. Geist. 1988. Behavior responses and reproduction of mule deer does following experimental harassment with an all-terrain vehicle. Canadian Field-Naturalist 102(3):425-429.

Youmans, C. C. 1991. Analysis of long-term trends in elk vulnerability on the Bitterroot National Forest in relation to selected predictor variables. Pages 159-167 *in* A. G. Christensen, L. J. Lyon, and T. N. Lonner, compilers. Proceedings of the elk vulnerability symposium. Montana State University, Bozeman, Montana.

Youmans, H. B. 1992. Statewide elk management plan for Montana. Montana Department of Fish, Wildlife and Parks, Helena, Montana. 171pp.

CHAPTER 7

CARNIVORES

EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE
A Review for Montana

www.montanatws.org

MONTANA CHAPTER OF THE WILDLIFE SOCIETY

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ABSTRACT

Members of the mammalian order Carnivora have a wide variety of responses to human recreation. Some species like skunks, raccoons, and coyotes have adapted to the presence of humans and to human activities including recreation. These species have been and will probably continue to be impacted only in localized areas of intense recreational or developmental activity. For other species, human recreational activities are documented or suspected to have significant adverse impacts. Because they are listed under the Endangered Species Act and, consequently, have been subjected to significant research on decimating factors, evidence of such impacts is most compelling for grizzly bears and wolves. Some carnivores like black bear, mountain lion, lynx, bobcat, wolverine, fisher, and marten, are subject to hunting and trapping either directly or incidental to hunting and trapping efforts for other species. For these species, most evidence of recreational impacts comes from studies designed to evaluate the impacts of hunting and trapping activity and other, less direct, recreational impacts have not been adequately researched. Research motivated by take (hunting and trapping) typically focuses on demographic impacts and population assessment rather than on habitat impacts. Correspondingly, our reports here may understate the importance of habitat deterioration caused by recreational activities other than hunting and trapping. Research on recreational impacts is inadequate on carnivores as it is for most other species. Correspondingly, in addition to documented impacts, we have included some informed thought on probable impacts. This information is provided to increase the probability that decisions on siting of recreational facilities or implementation of recreational programs will err on the side of avoiding adverse impacts.

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INTRODUCTION

The impact of recreational activities on carnivores in the Rocky Mountains, particularly in Montana, has received minor attention to date by research scientists. The task of summarizing carnivore literature with respect to recreational impacts was simplified because of a paucity of literature. However, this same lack of information complicated development of management recommendations. Each species section concludes with management guidelines/recommendations that are based on individual species ecology, carnivore conservation strategies, and impacts of human disturbance.

We have observed that year-round use of commercially available recreational vehicles into remote habitats is now common. These areas previously were isolated due to distance, season of year (e.g., winter), and lack of trails and roads; now, there is no season when these areas are "quiet" (from human use). These new and frequent intrusions are of concern, particularly for carnivore species that characteristically seek secluded areas for production and rearing of young.

We considered the following statements integral to the development and context of this document, particularly as they apply to the management guidelines:

1. Management guidelines need to be based on biological parameters (reproductive rates; behavioral characteristics, such as susceptibility to habituation, disturbance, displacement; and specialized habitat requirements, such as denning, rendezvous, and foraging sites) and, the impacts of habitat fragmentation.
2. Interspecific competition among carnivores for limited numbers of prey can be significant, particularly in disturbed, altered, and fragmented habitats.
3. Several species of carnivores have large habitat area requirements, specialized habitat needs, low reproductive potential, and low dispersal/colonizing abilities that result in these animals being especially sensitive to habitat fragmentation and isolation.
4. In many landscapes, occurrence of habitats that fill the specialized habitat requirements of carnivores, particularly ursids and mustelids, have been reduced as a result of human developments (e.g., subdivisions, reservoirs, roads), logging practices (loss of old growth/structurally mature conifer stands with multiple canopies, snags, and downfall), and recreational use/developments in forest habitats and important landforms such as alpine cirques (e.g., ski resorts, snowmobile trails/play areas, heli-skiing, and extreme snowboarding).

CANIDAE
GRAY WOLF

Introduction

Gray wolves (*Canis lupus*) were extirpated from the western United States by the 1930s through government and private efforts (Day 1981, Ream and Mattson 1982). However, in the 1960s and 1970s public sentiment changed to become increasingly pro-predator and ecosystem oriented. Large carnivores were recognized in their role of maintaining ecosystem integrity and biodiversity (Paquet and Hackman 1995, Noss 1995, Noss et al. 1996). The federal Endangered Species Act (ESA) granted full protection to Montana's wolves by listing them as an endangered species in 1973. The majority of the public supported wolf recovery, and Congress mandated that wolves be recovered in the United States. Wolves began recolonizing northwestern Montana in the late 1970s via dispersal from Canada (Ream et al. 1991, Boyd et al. 1995, Boyd-Heger 1997). The northern Rocky Mountain Wolf Recovery Plan was completed in 1987 (USFWS 1987) as a guideline to management and future delisting. The primary objective of the plan is to remove the northern Rocky Mountain wolf from the endangered and threatened species list by securing and maintaining a minimum of 10 breeding pairs of wolves in each of the 3 recovery areas (northwest Montana, central Idaho, and the greater Yellowstone area) for a minimum of 3 successive years (USFWS 1987). Upon delisting, wolf management would become the responsibility of the states of Montana, Idaho, and Wyoming.

Wolves are a highly mobile species and commonly disperse several hundred kilometers (Fritts 1983, Ballard et al. 1987, Boyd and Pletscher 1999) so recolonization may occur at a fairly rapid rate. Wolf recovery is still in progress in Montana. During spring 1999, 7 wolf packs inhabited western Montana, both on public and private lands. Additionally, natural recolonization was augmented by wolf reintroduction in central Idaho and Yellowstone National Park in 1995 and 1996 (Bangs and Fritts 1996, Fritts et al. 1997). Wolves from Yellowstone and Idaho have dispersed to western Montana and will continue to do so at an increasing rate as recovery proceeds. For wolf population updates refer to http://www.r6.fws.gov/wolf. The return of this controversial, charismatic carnivore has precipitated questions from the public and wildlife managers about habitat requirements, impacts of wolves on wildlife and recreation, and impacts of recreation on wolves. Wolves are a fairly resilient species and can coexist with people if people will tolerate them. However, recreational activities have the potential to displace wolves, cause wolf mortalities, and impact wolf recovery and, therefore, need to be addressed. Good management practices, based on sound scientific data, and public outreach increase tolerance of wolves and enhance recovery.

Habitat

Wolves historically had the broadest, worldwide geographic distribution of all mammalian species, with the exception of humans. Wolves have existed in a broad spectrum of landscapes in the northern hemisphere, occupying nearly all habitat types except true deserts. Their wide distribution implies inherent ecological flexibility and lack of habitat specificity. Wolves tend to be habitat generalists in terms of vegetation and terrain (Mech 1970, Mladenoff et al. 1995) but select certain physiographic traits, such as slope and elevation, within their range (Paquet et al. 1996, Boyd-Heger 1997). For most species, preferred habitat is usually regarded in terms of vegetation attributes. Wolves, however, do not necessarily fit into this classification regime, and require only 2 key habitat components for their r existence: (1) an adequate, year-round supply of wild ungulates, and (2) freedom from excessive persecution by humans (Fritts et al. 1994, Fritts and Carbyn 1995). If these 2 criteria are met, wolves can survive nearly anywhere.

By 1940, intensive wolf persecution had reduced wolf distribution in the contiguous United States by 98%, allowing wolves to remain only in areas with minimal human access and an absence of wolf-human conflict (Thiel et al. 1998). This created the illusion that wolves preferred areas of remote wilderness. However, wolf recovery in the Midwest has occurred in semi-wild landscapes occupied by humans (Mech 1995, Mladenoff et al. 1997, Haight et al. 1998). Western wolf recovery has occurred in areas of lower elevation and human presence (Fritts and Carbyn 1995, Paquet et al. 1996, Boyd-Heger 1997, E. Bangs, USFWS, personal communication). Ungulate winter ranges, a critical factor for wolf survival, are usually located in valley bottoms with lower snow depths. Primary wolf prey in the Rocky Mountains are white-tailed deer, mule deer, elk, and moose while beaver and smaller mammals serve as supplemental prey. Numbers of wolves are directly related to ungulate biomass (Fuller 1989, Weaver 1994, Weaver et al. 1996). Habitat used by Rocky Mountain wolves has been correlated with ungulate distribution and abundance (Carbyn 1974, Huggard 1993, Weaver 1994, Kunkel 1997, Boyd-Heger 1997). Lower-elevation landscapes contain productive riparian areas and higher year-round concentrations of wild ungulates, livestock, recreationists, and human development. Some sectors of the public have expressed concern that the presence of endangered wolves may restrict their recreational opportunities or impact their lifestyle. Human coexistence with wolves inevitably results in some conflicts, but present federal management emphasizes minimal restrictions on land use to accommodate wolf presence.

Recreation

Trapping/snaring - Trapping and snaring are recreational activities for harvesting furbearers such as fox, coyote, wolverine, lynx, and bobcat. Although it is illegal to trap wolves in Montana, wolves are vulnerable to trapping and snaring and may be captured incidentally while trapping other furbearers. The size of the trap, frequency of trap-checks, method of anchoring, and attitude of the trapper all contribute to the impact trapping has on wolves. Trappers that incidentally capture wolves can often successfully release wolves with minimal damage if the wolf has been in the trap less than 24 hours.

Fox-sized leghold traps (#2s) occasionally hold wolves. Leghold traps and snares designed to capture coyotes, lynx, wolverines, and bobcats (#3s) will often hold wolves firmly. Wolves may break the drag or staking device and escape with a trap on a foot. These animals may slough the foot or die from trap-related injuries. Trappers who incidentally capture a wolf, sometimes kill the wolf when confronted with the difficult situation of attempting to release the struggling animal.

D. Boyd (unpublished data) incidentally caught and held wolves overnight on 2 occasions in #2 leghold fox traps in Minnesota. Murie (1944) reported that many wolves were caught in fox traps outside of Mount McKinley [Denali] National Park, Alaska. Some remained in the trap until the trapper came along and killed them. However, many of these incidentally captured wolves ran off with fox traps on their feet. Murie (1944) reported that a trapper caught a wolf that already had a trap attached to another foot. Additionally, Murie found a trap inside the park with a wolf toe in it. Denali wolves have experienced trap-related injuries and mortalities through the present time (T. Meier, USFWS, personal communication).

A minimum of 4 wolves have been incidentally captured by coyote trappers in Montana since 1990. A wolf was foot-snared by a coyote trapper in November 1991 in the Murphy Lake area. The wolf apparently stepped through a coyote neck snare and became entangled. The trapper called wildlife officials to report the incident, and agency personnel radio-collared the wolf and released it on site. Another wolf was caught in a coyote trap in late December 1998 in the Stevensville area. The trapper called agency personnel who subsequently radio-collared the wolf and released it on site. Another wolf was trapped near Stryker in late December 1998. Agency biologists saw the wolf dragging a trap on its left front foot and attempted unsuccessfully to capture the animal. Several weeks later this wolf's tracks were observed with a deformed left front foot indicating it had apparently shed the trap and retained the damaged foot. Another wolf was caught by a coyote trapper in March 1999 and escaped with a trap on its foot in the Ninemile area. Agency biologists attempted, unsuccessfully, to dart the Ninemile wolf and remove the trap. This animal was observed by agency personnel 2 weeks after it was trapped; the wolf was limping severely with the trap firmly attached to the right front foot. Two of 14 Sawtooth pack wolves captured by the U.S. Fish and Wildlife Service (USFWS) in 1996 were missing toes that may have been from healed trap injuries, and 2 more pack members had large calcium deposits above the paw that may have been from old trap injuries (J. Fontaine, USFWS, personal communication).

Hunting with hounds - The Montana mountain lion season (harvest and chase) in occupied wolf habitat is open 4 to 6 months per year, depending upon the district. Lion hunters turn their hounds loose to run lions in areas that may contain resident wolves. These hounds are often more than 1 km ahead of the houndsmen, uncontrolled, and may encounter territorial wolves. Some of these encounters have resulted in serious combat between wolves and dogs, and at least 9 hounds have been killed by wolves in Montana and Idaho since 1990 (J. Fontaine, USFWS, personal communication). Though this is a relatively rare occurrence, lion hunters have expressed strong fear of losing hounds to wolves. Armed lion hunters may encounter wolves and opportunistically kill them, especially if wolf-lion hound conflicts are perceived as a serious threat. Wolves scavenge on old lion kills and occasionally displace lions from a fresh lion kill to procure the carcass (Kunkel, 1997, D. Boyd, unpublished data, T. Ruth, Yellowstone National Park, personal communication). Thus, a pack of hounds trailing a lion could encounter a pack of wolves along the lion's trail. Although well-trained hounds usually will not follow wolf tracks, some hounds may naively pursue wolf scent and force an encounter with a pack. Baying hounds may serve as an attractant to residential wolves defending their territory against trespass.

In Wisconsin, several hounds chasing rabbits, bears, coyotes, and bobcats, have been killed by wolves (A. Wydeven, Wisconsin Department of Natural Resources, personal communication). From 1976 to 1997, a total of 19 hounds were killed by wolves in hunting situations when the wolf population ranged from 15-25 in all of Wisconsin. By 1998, 4 beagles were killed by wolves while chasing rabbits, and 10 more hounds were killed by wolves while pursuing bears and other predators. In 1998, the Wisconsin wolf population had increased ten-fold to approximately 200 animals, which contributed to the significant increase in wolf depredation on dogs. As wolf recovery continues in the Midwest and West, conflicts between wolves and houndsmen may increase.

Big game hunting - Many illegal wolf killings occur during big-game season when hunters with firearms travel through wolf habitat. Some wolves may be misidentified as dogs or coyotes and killed mistakenly. Others are killed intentionally by hunters who dislike wolves, fear wolves, or see them as a threat to their hunting opportunities. Of all recreational activities in Montana, big-game hunting probably has the greatest potential for detrimental impact to wolves. Fifteen of 30 wolf mortalities in northwest Montana, southeast British Columbia, and southwest Alberta were caused by shooting (Boyd and Pletscher 1999). Wolves are legal game in southeast British Columbia and southwest Alberta. Four of 11 Mexican wolves reintroduced in Arizona were illegally shot during the big game hunting season (D. Parsons, USFWS, personal communication). Intensive public outreach and education programs are necessary to open communication between managers and the public to minimize illegal wolf mortality during hunting season.

Coyote hunting - Although Rocky Mountain wolves are 3 to 4 times as large as coyotes, wolves have been misidentified as coyotes and illegally shot. Coyotes may be killed yearlong in Montana, creating a continuous opportunity for mistaken-identity wolf killings. Aerial gunning of coyotes, allowed under Montana law, is administered and permitted by the Department of Livestock. Wolves could be mistakenly taken in the process of hunting coyotes (E. Bangs, USFWS, personal communication). In fact, wolves have been mistakenly taken in North Dakota (T. Meier, USFWS, personal communication). Predator calling to shoot coyotes and other predators is increasing in popularity. Wolves may approach a hunter using a predator call and become vulnerable to shooting. Managers should make educational materials available, with canid identification tips, similar to the grizzly bear/black bear materials, in sporting goods stores and Montana Fish, Wildlife and Parks (MFWP) offices.

The wolf population in Wisconsin incurred several illegal wolf mortalities during concurrent coyote and deer hunting rifle seasons. During 6 years (from 1979 to 1986), a minimum of 4 wolves were killed during the annual 9-day rifle deer season while coyote season was open (A. Wydeven, Wisconsin Department of Natural Resources, personal communication). In an effort to reduce wolf mortalities, the Wisconsin Department of Natural Resources banned coyote hunting during the 9-day deer rifle season starting in 1987. Subsequently, illegal wolf mortalities decreased to a total of 2 during 11 years of the rifle deer season, despite a 10-fold increase in wolf numbers.

Non-hunting recreation with dogs - People often recreate with their dogs for companionship while hiking, camping, skiing, or dog-sledding. Recreationists may be unaware of the problems dogs can cause wild wolves, with potential immediate and long-term effects. Dogs encountering an occupied wolf den or rendezvous site will disturb the wolves. This could result in abandonment of these sites and will likely result in the death of the dog.

Additionally, dogs are a very effective disease vectors for wolves, and vice versa. Canine parvovirus was apparently introduced to the wolves of Isle Royale National Park, Michigan, by a visitor with a dog in the 1980s. Subsequently, pup mortalities increased and the Isle Royale population decreased to record low numbers. Parvovirus was introduced to wolves in the Glacier National Park area in 1989 and resulted in increased pup mortalities (Boyd et al. 1993). Wolf populations in Minnesota and Wisconsin experienced increased pup mortalities and decreased recruitment following the introduction of Parvovirus in the late 1970s (Goyal et al. 1986, Mech and Goyal 1995, A. Wydeven, Wisconsin DNR, personal communication). Like parvovirus, rabies, distemper, and parasites are easily transferred from dogs to wolves and may impact wolf populations. In winter, sled dog teams may spread infectious diseases to wolves, which has generated concern among biologists in Denali National Park, Alaska (T. Meier, USFWS, personal communication).

Snowmobiles - Wolves often take advantage of easy travel on compacted snowmobile trails. Traveling on human-compacted routes has both positive and negative impacts on wolves. Human activities that compact snow (e.g., snowmobiling, cross-country skiing, road-plowing) provide easy travel routes for wolves into areas that would otherwise be difficult to reach in deep snow (Paquet et al. 1996). Wolves have a lighter foot loading than most ungulates (Telfer and Kelsall 1984) and often travel on snow that will not support their prey (Peterson 1977, Paquet 1989). Wolves have difficulty moving in snow deeper than 50 cm (Pulliainen 1965) and normally avoid areas of consistently deep snow. The ease of travel along travel routes compacted by humans may increase effects of predation on ungulates (O'Karma et al. 1995) as previously unexploited ungulate ranges are discovered by wolves. Snowmobiles in Canada made well-used trails to elk wintering areas that wolves had previously not utilized, causing increased wolf depredation (P. Paquet, University of Calgary, Alberta, personal communication). Wolves may follow snowmobile routes into less remote areas with more human presence and increased potential for conflict (e.g., from forests to ranches). Trappers commonly set traps and snares along snowmobile routes for furbearers that may result in incidental capture of wolves.

Snowmobilers occasionally chase wolves and shoot them or run them over to kill them. A wolf was chased down and run over by 2 snowmobilers on Birch Lake near Babbitt, Minnesota, in December 1997 (L. Aylsworth, International Wolf Center, personal communication). The wolf was severely injured and had to be killed by a conservation officer. In February 1998, a wolf was chased and run over by a snowmobiler in an open area near Grygla, Minnesota (A. Chavez, Agassi Wildlife Refuge, personal communication). The snowmobile severed the wolf's vertebrae, and the wolf crawled approximately 100 m before succumbing. In January 1999, a pack of wolves was feeding on a deer carcass on Lake Vermillion near Tower, Minnesota, when a snowmobiler chased them and shot 2 of them (L. Aylsworth, International Wolf Center, personal communication). Another wolf was killed near Hatcher Pass, Alaska, after a snowmobiler had run over a wolf repeatedly and then shot it (L. Aylsworth, International Wolf Center, personal communication). In Canada, wolves are legally harvested by armed snowmobilers. In the Rennie Lake area, Northwest Territories, hunters on snowmobiles killed 635 wolves in the winter of 1998 (D. Cluff, NW Territories Wildlife Department, personal communication).

Den site disturbance - Wolves use a den site intensively for approximately 2 months in late spring (Mech 1970). The pups cannot maintain their own body temperature during the first 3 weeks of life and are dependent upon the alpha female to lie with them in the den and warm them (Mech 1970, Mech et al. 1991). During these critical early weeks, the pups are especially vulnerable to den site disturbance that may keep the female away. Wolves will sometimes abandon a den if disturbed by humans and move the pups by mouth to another den (Mech et al. 1991). During this moving process, the pups are exposed to harmful elements such as inclement weather, swollen rivers, and other predators.

Sensitivity to disturbance at den sites and subsequent abandonment varies greatly among individual wolves. Distribution of prey and suitable alternative dens may also affect den site fidelity. One incident of disturbance at the den may cause abandonment for some wolves. Others will tolerate some human disturbance (Thiel et al. 1998) and may not abandon dens unless there are repeated or severe incidents of disturbance. Human disturbance may limit re-use of dens (Stenlund 1955, Kozlov 1964), but some disturbed dens are used again the following year (Murie 1944, Stephenson and Johnson 1972).

Recreational wildlife watching by tourists appeared to contribute to the death of a litter of wolf pups in Yellowstone National Park (L. Thurston and D. Smith, Yellowstone National Park, personal communication). In early April 1997, the alpha female (#9) of the Rose Creek pack denned 0.8 km from the Lamar Valley Road in Yellowstone National Park in a new den that was visible from the road. Concurrently, her daughter (#18) denned in the traditional den more than 3 km from the road with no human disturbance. There was very little traffic on the road when #9 denned. However, road traffic increased soon after #9 whelped and her den and pups became an attraction for park visitors. By 0530 each morning, many vehicles would park along the road in sight of #9's den, making considerable noise and movements (L. Thurston and D. Smith, Yellowstone National Park, personal communication). Up to 100 vehicles per day would park along the road near the den site. The commotion apparently disturbed the wolves and possibly precipitated movement of the denned pups approximately 1 month after whelping (L. Thurston and D. Smith, Yellowstone National Park, personal communication). On May 12, #9 moved her pups 0.8 km to a den site farther away, but still visible, from the road. Concurrently, most of the other adult wolves ceased tending #9's litter and shifted pup provisioning and den attendance to #18's den. Three weeks later #9 attempted to move her pups across the road toward the rest of the pack, but she was unable to lead them past parked visitors. One week later, #9 succeeded in crossing the road with her pups, but the task of crossing a raging river that now divided her from the pack proved too difficult. The pups were stuck at a rendezvous site between the road and the river. Wolf #9 traveled between #18's den and her own pups for several weeks but the frequency of visits to her pups eventually tapered off. Researchers observed a coyote biting one of #9's pups at the rendezvous site. None of #9's pups were observed after mid-June, and all were presumed dead.

Joslin (1966) removed 2-week-old pups from a den, tagged them, and put them back in the den; the den was abandoned by the next day. Murie (1944) reported that wolves had abandoned a den after 4 young pups were removed from it. Chapman (1977) reported abandonment of a den after disturbance by humans. In Yellowstone National Park in 1996, female #9 moved her 3-week-old pups to a new den, apparently in response to a low-level wildlife survey helicopter flight over her den (D. Smith, Yellowstone National Park, personal communication).

The traditional den site of the Ninemile wolves near Missoula, Montana, was logged and the den obliterated during the winter of 1997 prior to denning season. Rather than leave the drainage entirely, the wolves established a new den less than 0.8 km away. From this new site, the wolves could hear chainsaws running, trees falling, and heavy equipment working, but remained there through the duration of the denning period. Logging occurred in the new 1997 den area just prior to the 1998 denning season, and the wolves responded by establishing a new den 0.6 km away and successfully raised pups there. The den site of the Murphy Lake wolves was logged in 1994 after the wolves had abandoned the site, and the wolves used the same den hole the next 2 years (J. Fontaine, USFWS, personal communication).

Wolves often bark or howl when disturbed at a den or rendezvous site. Stephenson (1974) stated, "The distance from the den and pups at which human presence first causes wolves to vocalize could probably be viewed as the distance at which human presence causes intense anxiety to adult wolves rearing pups." The greatest distance that wolves at a den unequivocally detected a human visually or by scent is less than 1.5 km (Stephenson and Ahgook 1975). To minimize human disturbance, Chapman (1977) recommended closing the area within a 2.4 km radius around traditional dens in Denali National Park from 1 month before denning until 3 months after denning begins. Mech et al. (1991) recommended den area closures in Yellowstone National Park for a 1.6 km radius around the denning area for 1 month before denning and to 2 months after denning.

Rendezvous site disturbance - When the pups are approximately 2 months old, the pack moves from the den area to a staging ground called a rendezvous site. These sites are safe areas where the adults leave the pups and return with food for the pups after successful hunts. Rendezvous sites are characterized by well-used wolf trails, beds, bones, and scats. Wolves may use one or several rendezvous sites during a summer. The pups may be left at a rendezvous site without an adult present, but more often at least 1 adult remains at the site and serves as a guardian. Wolves may be sensitive to disturbance at rendezvous sites and may abandon the site in response to human activity. Wolves exhibit a wide variety of responses to human disturbance at rendezvous sites, similar to the range of behavior reported in the denning section above. The Ninemile wolves abandoned their summer rendezvous site after a human unintentionally walked into it once (M. Jimenez, USFWS, personal communication). However, the wolves did not abandon an occupied rendezvous site after initiation of a helicopter logging operation that removed more than 200 loads of logs less than 1 km from the wolves, with daily low-level helicopter overflights (Jimenez 1995). A particularly tame female wolf from the East Fork pack in Denali National Park, Alaska, moved her pups closer to the park road from a more distant den (Thiel et al. 1998, T. Meier, USFWS, personal communication). These pups were frequently seen along the road by park visitors at close range, apparently unbothered by human presence. This move provided excellent viewing and photographic opportunities, but prompted concerns from biologists about wolf safety and risk of habituation. The dominant female of this pack was relatively shy and rarely observed.

Wildlife photographers and tourism - The wildlife photography industry promotes full-frame shots of captive animals in wild-looking settings, suggesting that the photographs were taken in the wild. This encourages both professional and amateur photographers to occasionally engage in unethical behavior to obtain photographs of wild wolves at dens or on kills. Such close-range encounters may disturb wild wolves, alter wolf behavior, or cause wolves to expend extra energy eluding pursuers, and may result in den site abandonment. On the other hand, if human disturbance occurs repeatedly, some wolves may eventually become habituated and accept human presence. This is probably more detrimental than fleeing disturbance because approachable wolves become easy targets for illegal killing.

Recreational howling - Wolf-howling tours with wolf advocacy groups, park personnel, and recreationists are becoming increasingly popular. Wolves frequently respond to imitated wolf howls made by humans and sometimes approach howlers to within 35 m (Joslin 1966). In Algonquin Park, Ontario, hundreds of tourists show up each night for the evening howling session led by park-sanctioned personnel. Although it is an incredible thrill to hear the howls of wild wolves undulating through the forest, solicited howling can be stressful and disrupt pack behavior. Resident wolves may respond to howl stimuli as though trespassing wolves were invading their territory. Time and energy are devoted to replying and approaching the source of the howling. Repeated howling at dens and rendezvous sites have caused wolves to abandon the area and move their pups.

Anthropogenic linear features (roads/seismic lines/ORV trails) - The scale of a road will determine whether it becomes a travel corridor or a movement barrier to wolves and other carnivores. Wolves commonly use anthropogenic linear features as travel routes. Roads, snowmobile trails, cross-country ski trails, and ORV trails create easy travel for wolves, and they may seek them out preferentially. However, there is a trade-off between easier travel and increased mortality due to human encounters. Boyd and Pletscher (1999) reported that the mean distance to a human linear feature for human-caused wolf mortalities (0.13 km) was significantly greater than for nonhuman-caused mortalities (0.85 km) (U = 318.5, n = 36, $P \leq 0.001$). Twenty-one of 25 human-caused wolf mortalities occurred at less than 200 m (within shooting distance) of a human linear feature in the central Rockies (Boyd and Pletscher 1999).

In Yellowstone National Park, "wolf jams" (lines of cars on the road) of wolf enthusiasts have sometimes become barriers impeding wolf movements during wolf hunting sequences and when wolves are bringing food to pups at dens. Additionally, several wolves have been killed by vehicle collisions in Montana. Fifteen of 27 wolf mortalities in Banff National Park were caused by vehicle collisions (Paquet et al. 1996). Highway traffic may be a physical and/or psychological impediments to wolf movement and limit access to suitable wolf habitat (Paquet et al. 1996).

Studies in Minnesota, Wisconsin, Michigan, and Ontario have shown a strong negative relationship between increasing road density and the presence of wolves (Thiel 1985, Jensen et al. 1986, Mech et al. 1988, Fuller 1989). Wolves generally were not present in the Midwest where road densities exceeded 0.58 km/km^2 (Thiel 1985, Jensen et al. 1986, Fuller 1989). In the rugged topography of the Rocky Mountains, wolves tend to be found closer to roads and in areas of higher road density than in the Midwest (Boyd-Heger 1997). This occurs because landscape attributes preferred by wolves (ungulates, wolf den and rendezvous sites, shallower snow) are found in valley bottoms in mountainous terrain, as are the majority of roads. In the Ninemile area wolves have existed for a decade in a valley where road densities exceed 2.5 km/km^2 (Boyd-Heger 1997 M. Jimenez, USFWS, personal communication).

Thurber et al. (1994) examined the response of wolves to different road types and human presence at the boundary of the Kenai National Wildlife Refuge in Alaska. Radio-collared wolves avoided oil field access roads open to public use but were attracted to a gated pipeline access road and secondary gravel roads with limited human use. Thurber et al. (1994) speculated that roads with low human activity provide easy travel corridors for wolves.

Conclusions

Wolves are intelligent, learn quickly, and exhibit more behavioral plasticity than many other species, causing a wide variation in adaptability of individuals. Some individuals within a pack may be extremely sensitive to human disturbance while others may be tolerant of disturbance. Thus, the overall impacts of recreational disturbance are difficult to assess or predict for wolves. Colonizing wolf populations that have recently come into contact with humans may be more sensitive to human disturbance than well-established populations that have coexisted with humans for many generations. Recovering wolf populations in Montana, Wisconsin, and Minnesota have become more habituated to human presence with increasing time since recolonization (Thiel et al. 1998, Hart 1999, D. Boyd, unpublished data, M. Jimenez and S. Fritts, USFWS, personal communication). One could argue that if wolves are to recover, they will have to learn to coexist with humans and become insensitive to human disturbance. However, habituation to human presence may increase the chances of livestock depredation or illegal killing of wolves. Harassment of fragmented, low-density wolf populations could result in increased mortality and slow the rate of recovery. Humans are responsible for the majority of wolf mortalities in many wolf populations. These mortalities occur directly through shooting and trapping and indirectly through den abandonment due to disturbance, increased energetic costs, vehicle collisions, and habituation in park situations leading to mortalities elsewhere. Therefore, managers have an opportunity to influence wolf recovery through education and management of wolf-human encounters. Findings from large, well-established wolf populations in Minnesota, Alaska, and Canada may not necessarily be applicable to fragmented, recovering populations in Montana and other western states. A conservative approach to wolf management should be used in Montana to meet recovery goals.

COYOTE

Life History and Habitat Needs

The coyote (*Canis latrans*) is distributed continuously throughout North America with the exception of northeastern Canada (Samuel and Nelson 1982, Voigt and Berg 1987). They are found throughout Montana. Coyotes occupy many diverse habitats and have proven to be quite adaptable; they are even able to survive in urban areas of large cities (Bekoff 1982). Coyotes generally demonstrate social organization through formation of pair bonds (Bowen 1982, Windberg and Knowlton 1988, Gese et al. 1989) and, at times, packs or groups (Bekoff 1982, Gese et al. 1988b). Territoriality generally is displayed by resident pairs or groups with home ranges showing little or no overlap (Gese et al. 1988a, Windberg and Knowlton 1988, Gese et al. 1989). Transient or dispersing members of the population, primarily sub-adults (<2 years of age) or adults unable to establish social status, maintain larger home ranges (Gese et al. 1988a, Windberg and Knowlton 1988).

Coyotes eat a wide variety of food items including berries, insects, birds, reptiles, large and small mammals, and carrion (Bekoff 1982, Gese et al. 1988b). Coyotes are able to hunt individually as well as in groups, which are generally formed during the winter (Gese et al. 1988b). Bowin (1982) and Gese et al. (1988b) observed an increase in the amount of large ungulates present in coyote diets as group size increased.

Reproduction may occur in yearling females but occurs primarily in adults 2 years old or older (Bekoff 1982, Voigt and Berg 1987). Gestation is approximately 63 days with an average litter size of 6 pups. Litter size may be dependant on food availability, habitat quality, and age of the female (Bekoff 1982). Sex ratios generally do not differ significantly from 50:50 (Gese et al. 1989), but may vary with the level of control to which a population is subjected (Bekoff 1982). A net survival rate between 33% and 38% may be necessary for population stability (Knowlton 1972, Nellis and Keith 1976, Bekoff 1982).

Coyote mortality rates differ by age group, social status, and the level of human control to which the population is exposed (Bekoff 1982, Gese et al. 1989, Hamlin 1997). In heavily exploited populations, man is the primary source of mortality (Pyrah 1984, Windberg et al.1985, Gese et al. 1989). Currently coyotes are classified as predatory animals in Montana. Regulation consists only of the requirement that a non-resident trapper purchase a trapping license to harvest coyotes. Hunting, trapping, and predator control activities were actively pursued in the past in Montana and persist in some areas today (Hamlin 1997). A bounty was placed on coyotes in the 1800s, and in the early 1900s the Montana Fish and Game Department maintained employees solely for predator control (Smith 1929, Hamlin 1997). Although predator control activities occur yearly within the state, mortality rates due to hunting and trapping are largely determined by fur prices (Giddings 1995), which were high in the 1970s but have declined significantly since that time. Despite extensive predator control and occasional high hunting pressure, coyote populations in Montana have maintained or increased in many areas (Hamlin 1997). The majority of management activities conducted by state and federal agencies consist of population control of coyote to reduce the economic impact this species may impose upon local ranchers and land owners.

Recreational Effects

The effects of recreational activities have not been specifically studied for coyotes. Possible negative influences of recreational activities include direct mortality, disruption in prey distribution, and genetic contamination. Recreational activities that commonly result in direct mortality include hunting, trapping, and vehicular accidents. Douglass and Ernst (1985) observed decreased coyote activity near roads on which vehicular use increased during mining operations. Changes in prey species use of areas subject to human activity may also affect canid populations in that area. Increased human recreation generally means an increase in domestic canid use. Interbreeding between domestic dogs and coyotes can occur; the offspring of such matings are possibly fertile (Bekoff 1982).

Recreational activities that result in direct mortality or changes in habitat use are not likely to cause serious, long-term declines in coyote populations within Montana. Extreme measures taken in the late 1800s and early 1900s to exterminate the coyote throughout much of the western United States were largely unsuccessful (Hamlin 1997). The coyote has proven to be highly adaptable to human activities, and although immediate use of an area may change, the overall coyote population will not likely be influenced in any measurable manner. The effects of coyote interbreeding with domestic dogs on coyote population are not known.

Conclusions

Coyotes have high reproductive rates and have been able to overcome high mortality rates, even in areas of targeted removal. The majority of management programs concerning coyotes are designed to reduce their numbers through predator control. Specific management recommendations regarding recreational activities and coyotes are not available. Information regarding impacts of human recreational activities upon coyotes does not appear to be an urgent need. Given the ability of coyotes to sustain themselves, even under most removal efforts, it appears that secondary consequences of human recreational activities upon coyotes have been and will continue to be nominal.

RED FOX

Life History and Habitat Needs

With the exception of the western and southwestern portion of North America, red fox (*Vulpes vulpes*) are distributed across the continent and are prevalent across Montana. Red fox typically occupy diverse landscapes comprised of open land intermixed with brush or forested areas. Dense forests are considered unsuitable habitat for red fox (Samuel and Nelson 1982). The gray fox (*Urocyon cinereoargenteus*) may be an occasional visitor to the extreme southeast corner of the state as its known distribution includes western South Dakota and eastern Wyoming (Samuel and Nelson 1982).

Male and female red fox generally form breeding pairs and cooperate in raising pups (Samuel and Nelson 1982), although other social arrangements have been observed (Voigt 1987). Red fox dig dens or use abandoned burrows for birthing and raising pups. Territories are marked and defended by the male, which hunts and provides food for the vixen until the pups can be left alone. The vixen then cooperates in hunting activities while continuing to nurse the pups. Pups are born in the spring and disperse in the fall (Phillips et al. 1972). Occasionally adults will disperse from former home ranges and establish new territories (Samuel and Nelson 1982). Litter sizes vary depending on habitat quality, but average 5 young per female. Sex ratios are generally 50:50, although sex ratios skewed toward males have been observed (Samuel and Nelson 1982).

Red fox consume of a wide variety of food items, with fruits, insects, small mammals, and birds comprising the majority of their diet (Samuel and Nelson 1982, Voigt 1987). Fox often store food in caches for later consumption (Samuel and Nelson 1982).

Mortality rates vary depending on habitat conditions and proximity to man. Human-caused deaths (hunting, trapping, and vehicular collisions) generally comprise the majority of fox mortalities in studied populations (Storm 1965, Phillips et al. 1972, Samuel and Nelson 1982). In Montana, red fox are considered nongame wildlife and can be harvested at any time during the year with no limitations. Regulation is limited to the requirement that nonresident trappers must purchase a trapping license in order to harvest red fox.

Recreational Effects

Red fox are adaptive animals, able to exist near people and their activities. The presence of people and their pets may influence red fox use of an area without contributing to declines in the overall population. Increased mortality due to hunting, trapping, and other human causes may have an immediate, short-term effect on populations. However, the red fox is prolific and able to compensate for increases in mortality (Voigt 1987). Reduction in prey numbers due to habitat destruction is likely to have a greater effect on red fox than direct mortality (Voigt 1987). Red fox, which tend to avoid areas of high coyote populations (Sargeant et al. 1987, Harrison et al. 1989), may be able to take advantage of habitats that have less coyote activity due to human recreation.

Possible negative influences of recreational activities include direct mortality, changes in habitat use, and disruption in prey distribution. Recreational activities that commonly result in direct mortality include hunting, trapping, and vehicular accidents. Changes in prey species use of areas subject to human activity may also affect canid populations in that area. Increased human recreation generally means an increase in domestic canid use. Disease, the potential of becoming habituated to human activities, and exposure to human foods are also possible negative effects of increased human recreational activities.

Conclusions

Red fox have high reproductive rates, coexist readily with humans, and do not appear to be suffering adverse effects from human recreational activities. Specific Information needs for red fox regarding impacts of human recreational activities does not appear to be necessary at this time.

SWIFT FOX

Life History and Habitat Needs

Wild canids have been valued for their fur. This results in high human-induced mortality rates when fur prices are high. Although past harvest rates have periodically been high, canid predators have received little consideration in wildlife management, resulting in non-restrictive harvest regulations. Declines in swift fox (*Vulpes velox*) numbers however, have resulted in changes in management practices.

Swift fox formerly occupied a range from northern Texas and New Mexico, across the Great Plains, and into Alberta and Saskatchewan, Canada (Samuel and Nelson 1982, Scott-Brown et al. 1987). They are generally found in the prairie habitats of eastern Montana. Swift fox populations declined in the northern United States and Canada in the early 1900s, primarily due to predator-control activities, hunting and trapping, loss of prairie habitat, changing prey bases, and interspecific competition with other wild carnivores (Samuel and Nelson 1982, Scott-Brown et al. 1987).

Swift fox are believed to be monogamous, mating for life with the same partner (Kilgore 1969). However, few studies have been conducted and little supporting evidence has been obtained. Pups are born in early spring with litter sizes ranging from 1 to 8 with the majority of females giving birth to 4 or 5 pups (Samuel and Nelson 1982). Reported sex ratios varied from study to study but often did not differ significantly from parity (Scott-Brown et al. 1987). Strong family group associations are demonstrated, with pups remaining in natal dens until early June and with the family group unit late August (Samuel and Nelson 1982).

Swift fox have been called the most subterranean of all the foxes (Scott-Brown et al. 1987). Swift fox can excavate their own dens or enlarge burrows of smaller animals. Dens can be elaborate, having many entrances and are used yearlong (Scott-Brown et al. 1987).

Food habits consist primarily of rabbits, prairie dogs, rodents, birds, insects, carrion and vegetation (Kilgore 1969, Samuel and Nelson 1982, Zumbaugh et al. 1985, Scott-Brown et al. 1987, Zimmerman 1998). Large mammals have been found in swift fox scat and stomach samples but are believed to be primarily from scavenged carrion (Hines and Case 1991).

Mortality rates and causes vary by location. Coyotes were determined to be the major cause of mortality of swift fox in Kansas (Sovada et al. 1998). Man, primarily through trapping, shooting, and vehicular collisions, has been implicated in the general decline in swift fox numbers and continues to be a cause of mortality (Kilgore 1969, Samuel and Nelson 1982, Scott-Brown et al. 1987).

Status

In 1969, swift fox were declared extinct in Montana following a 16-year absence in trapping records (Hoffman et al. 1969, Zimmerman 1998). The decline in swift fox numbers resulted in the species being listed as a candidate species under the ESA with priority rating of 8 (Zimmerman 1998). Swift fox are considered a sensitive species by the Bureau of Land Management (BLM). Reintroduction efforts in Canada were initiated in 1983 with releases in Alberta and Saskatchewan (Zimmerman 1998). Swift fox were again observed in Montana in 1978 when a male was trapped in Custer county (Moore and Martin 1980). A study conducted in northeastern Montana resulted in the capture of 9 swift fox, only 1 of which was known to have been released during the Canadian reintroduction project (Zimmerman 1998). Den sites were observed, and reproducing females were captured during a study in north-central Montana, indicating that swift fox may be reestablishing themselves in Montana (Zimmerman 1998). Swift fox were classified as a furbearer in Montana in 1979, but trapping has not been allowed. Incidental take does occur occasionally; however, the trapper is not allowed to keep the carcass; which must be submitted to Montana Fish, Wildlife and Park officials.

Recreational Effects

The effects of recreational activities has not been studied for swift fox. Recreational activities that commonly result in direct mortality include hunting, trapping, and vehicular accidents. A variety of human activities have led to declines in swift fox numbers. Increased human encroachment as a result of increased recreational activities may result in shifts in habitat use. Changes in prey species use of areas subject to human activity may affect swift fox.

The presence of domestic dogs within swift fox habitat brings the possibility of introducing diseases, such as canine distemper, into swift fox populations. It is fair to speculate that diseases of domestic dogs may be a factor in the decline of swift fox, and research into this possibility would be important.

Unlike for the coyote and red fox, recreational activities, such as trapping and hunting can and have had impacts on swift fox numbers and distributions (Samuel and Nelson 1982, Scott-Brown et al. 1987, Zimmerman 1998). Few swift fox are currently present within the state. Swift fox numbers were greatly reduced during predator control activities conducted in the late 1800s and early 1900s (Samuel and Nelson 1982, Scott-Brown et al. 1987). The high susceptibility of swift fox to trapping activities may result in incidental trapping mortality (Scott-Brown et al. 1987).

Additional vehicular travel associated with increased recreation within swift fox habitat may also result in increased mortality due to vehicular accidents. Currently, swift fox appear to be established within Montana, but numbers remain low (Zimmerman 1998). Recreational activities that result in habitat destruction or direct mortality should be avoided if swift fox recovery is to continue.

Conclusions

Swift fox are quite susceptible to human-caused mortality resulting from predator control and recreational activities such as trapping.

Recommendations/Guidelines

Little information exists on the effects of recreational activities on swift fox, and managers have no set guidelines to follow when making decisions concerning recreational impacts. In swift fox habitat, surveys should be conducted to determine the presence of swift fox prior to establishing roads, trails, and recreation sites. Activities that may potentially inhibit swift fox distribution or increase mortality rates should be avoided. Given the current state of the swift fox population, off-road travel should not be permitted in areas swift fox inhabit.

Information Needs

Our understanding of swift fox ecology is limited, however, the number of studies being conducted is increasing due to the status of swift fox populations. It is not known whether recreational activities have had impacts upon swift fox populations resulting in habitat loss, introduction of diseases, or genetic hybridization with domestic dogs. Additional research is needed on these aspects for swift fox.

URSIDAE
BLACK BEAR

Introduction

Across North America, black bear *(Ursus americanus)* habitat can be characterized as forestlands that provide suitable food (Bray and Barnes 1967). Distribution of black bears in Montana has probably not changed during the past several decades. Black bears occupy forested habitats on both sides of the Continental Divide; the moist forests of the northwestern corner of the state are considered to be the most productive black bear habitat. From the northwest to the south and east, habitat quality and bear densities decline coincident with the precipitation gradient.

Approximately 45% of the state is occupied black bear habitat. Although black bears are seen occasionally in the eastern portion of the state, it is not considered occupied black bear habitat. Habitat quality, bear densities, and annual bear harvest are highest in the northwestern corner of the state and lowest in the south central area.

Distribution of grizzly bears in Montana does overlap with that of black bears. Herrero (1978, 1979) noted that although the 2 species are capable of coexisting in some forest ecosystems, the grizzly, because it occupied more open habitats, evolved a larger body size and more aggressive nature. Several studies in northern and northwestern Montana affirmed that grizzlies predominated in open shrub and burn areas (Jonkel and Cowan 1971, Shaffer 1971, Martinka 1972, Kasworm and Brown 1983). Data from the Rocky Mountain Front suggests a negative density relationship between grizzly bears and black bears (Aune and Kasworm 1989). Competition between the two species for space may be of greater importance than competition for food (Rogers 1983, Aune and Kasworm 1989, Kasworm and Thier 1991). Interspecific conflict may prevent black bears from making significant inroads in areas with flourishing grizzly populations, but black bear densities may increase if the grizzly population is suppressed by some other factor, most notably human activity (IGBC 1987).

Life History and Habitat Requirements

Black bears lead solitary lives, except for the brief period that a male and female spend together during the breeding season and the period that cubs are in the care of their mother (1 _ to 2 _ years). Black bears breed during the months of May, June, and July. Pregnancy lasts about 220 days. However, the fertilized egg is not implanted in the uterus until late fall, and embryonic growth occurs only during the 10 weeks prior to birth. Cubs are born in the winter den during late January or early February and weigh 6-9 ounces. They are weaned at 6-8 months of age but remain with their mother for at least 1 _ years (Jonkel and Cowan 1971). Some cubs may remain with the female for 2_ years (Rogers 1977). Subadult black bears generally disperse from their maternal home ranges as yearlings, males ranging farther than females. Female offspring are more likely than males to reside closer to or within their maternal home ranges (Powell 1987, Elowe and Dodge 1989, Mattson 1990).

Although Montana black bears may breed at 4 _ to 6 _ years of age, they have not been observed to successfully produce cubs until age 6 or 7 (Jonkel and Cowan 1971, Thier 1990). In contrast, black bears inhabiting more productive habitats in the eastern U.S. grow more quickly and mature earlier, successfully reproducing at age 2 _ to 3 _. Adult females in eastern North America breed every 2 years, but in the West, a breeding interval of 3 or more years is more common (Bunnel and Tait 1981). Research in Montana indicates an interval of at least 3 years between litters (Jonkel and Cowan 1971, Kasworm and Manley 1988, Simmons and Stewart 1989). More recent data from northwestern Montana bears (based upon tooth cementum estimations) indicates a breeding interval of 2.2 years (J. Brown, MFWP, personal communication). Average litter size reported for several Montana black bear populations was 1.6 (Jonkel and Cowan 1971, Brown 1990), 1.7 (Kasworm and Thier 1991), 1.68 (Simmons and Stewart 1989), and 1.8 (Aune et al. 1984).

Black bears are opportunistic omnivores, consuming both vegetation and meat. Intake of animal matter includes scavenging the remains of dead animals. Their unspecialized, relatively inefficient digestive system necessitates that they maximize the quality of the food items they ingest. Black bears seek out food items that provide starch, sugar, animal and plant protein, and animal and plant fats (Herrero 1978, Schwartz and Franzmann 1991).

The majority of a black bear's diet consists of plant material. Plant material comprises 75% of the yearlong diet in Yosemite National Park (Graber and White 1983), 80% in Great Smoky Mountains National Park (Eagle and Pelton 1983), 77% in Wyoming (Irwin and Hammand 1985), and 90% in Glacier National Park (Kendall 1986). Less than 2% of the diet of black bears in Idaho consisted of animal matter (Beecham and Zager 1992). In Wyoming and Montana studies, grasses, sedges, and forbs were the principle food items consumed during spring and early summer. Nuts (including those from whitebark pine, *Pinus albicaulis,* and limber pine, *P. flexilus*) and berries (especially huckleberries, *Vaccinium* spp.) predominated in late summer and fall (Shaffer 1971; Martin 1983; Kendall 1983, and 1986; Irwin and Hammand 1985; Mack 1986; Greer 1987; and Aune and Kasworm 1989). Insects, especially ants, and carrion were the principle non-plant foods consumed. Plants providing food for Montana black bear populations include common dandelion *(Taraxacum* spp.*),* goatsbeard *(Tragopogon* spp.*),* common horsetail *(Equisetum* spp.), cow parsnip *(Heracleum lanatum)*, angelica *(Angelica* spp.*)*, sweetvetch *(Hedysarum* spp.*)*, chokecherry *(Prunus virginiana)*, gooseberry *(Ribes* spp.*)*, hawthorn *(Crataegus* spp.), grouse whortleberry *(Vaccinium scoparium)*, huckleberry *(Vaccinium* spp.), mountain ash *(Sorbus* spp.*)*, and serviceberry *(Amelanchier alnifolia)* (Mack 1986, Kendall 1986). Important non-forested habitats used by black bears in their search for food include wet meadows, riparian areas, avalanche chutes, roadsides, burns, sidehill parks, and subalpine ridgetops.

Black bear movements and home range size reflect the patchy, scattered nature of important food sources such as mast crops (fruit of trees and shrubs including nuts, acorns, and berries). Unlike other species that defend a particular geographic area, bears move in response to the availability of food and may congregate at seasonally important food sources. Therefore, home ranges overlap and vary substantially season to season, and year to year. Home range size for marked black bears in Montana have varied between 53 and 225 square miles for males and 14 to 137 square miles for females (Aune and Brannon 1987, Greer 1987, Thier 1990, Kasworm and Thier 1991). Home range size is larger in the comparatively arid Rocky Mountain Front than in the forested northwestern corner of the state. Black bear densities have been estimated in various areas of northwestern Montana as 0.17 per square mile (Thier 1990), and 0.59 – 0.8 per square mile (Jonkel and Cowan 1971).

The highest quality black bear foods are typically products of lush vegetative habitats, often productive riparian lands (Schoen 1990), a factor contributing to conflicts with humans and other land uses. Given their inquisitive nature, opportunistic food habits, and natural role as a scavenger, it is no surprise that black bears will consume and readily become habituated to garbage, pet foods, fruit trees, and other foods associated with human habitation.

Hibernation, an adaptation to northern latitudes, reduces energy requirements during winter months when food is inadequate or unavailable due to snow cover. Physiological changes occur in the fall as food supplies diminish and air temperature declines. A bear’s heart rate declines from 40-50 beats per minute prior to hibernation to 8-10 beats per minute once in hibernation (Folk 1967). But, unlike classic hibernators, body temperature does not decline dramatically. Black bears remain fully arousable throughout hibernation. No one fully understands the unique physiological mechanisms that allow bears to survive for as long as 6 months without food or water and without urinating or defecating, but the most recent review of the physiology of hibernation in bears is provided in Hellgren (1998). It is thought that bears are able to switch from protein metabolism to lipid (fat) metabolism during the period of hibernation. Fat, rather than muscle tissue, accounts for the 15% to 25% weight loss that occurs during hibernation. Bears remain in a semi-hibernation mode for 3 weeks or more after emerging from their dens, during which time they eat and drink very little (Rogers 1987).

Black bear research has demonstrated a sequence of when the den is entered that is correlated with sex and age. Pregnant female enter earliest, followed by other adult females, subadults (females generally before males), and lastly, adult males (Reynolds and Beecham 1980, Lindzey 1981, Beecham et al. 1983, Schwartz and Franzmann 1987, Miller 1990b).

Mature males begin dispersing from the den sites earliest, followed by subadult males, adult females without cubs, adult females with cubs (Reynolds and Beecham 1980, Johnson and Pelton 1980, Tietje and Ruff 1980, Beecham et al. 1983, Rogers 1987, Schwartz et al. 1987, Miller 1990b). Females with cubs may emerge 1-3 weeks later than other bears and remain inactive in the vicinity of the den site for a longer period of time.

Montana research has identified den entry to occur between 14 October and 7 December and den exit between 21 March and 7 May (Jonkel and Cowan 1971, Kasworm and Brown 1983, Aune and Kasworm 1989, Mack 1990, Kasworm and Thier 1991).

Population Dynamics

While habitat quality is the ultimate limiting factor for bear densities (Schwartz and Franzmann 1991), 3 other factors are also important in determining bear numbers: nutrition, subadult dispersal, and infanticide (LeCount 1982). Bear densities can also be affected by hunting harvest.

Nutrition is the single-most important factor determining reproductive success in black bears (Rogers 1983; Beecham 1980b, and 1983). Bear reproduction and mortality rates vary annually with food supply (Miller 1990b). An ample food source in the fall is critical for survival of cubs-of-the-year as well as production of cubs the following spring. Females typically exhibit “skips” in their reproductive cycle following a fall with poor mast production. Delayed implantation is thought to be an adaptation to irregular food supply. If a pregnant female is not in good physical condition by fall or if forage conditions are poor, the fertilized egg will not implant in the uterus. In addition to serving as a birth control mechanism, delayed implantation allows adult females to conserve energy during the late summer and early fall.

Natural mortality of cubs varies from 12% to 48% annually (Erickson et al. 1964, Kemp 1972, Rogers 1977, DuBrock 1980, Elowe and Dodge 1989, Beck 1991). Cub mortality rate appears to be a function of several factors including spring weather, food supply, predator numbers, the mother's experience, and man-caused mortality (Beck 1991). Black bears, like brown bears, are among the species classified as "K selected," where K is the term for carrying capacity. For K-selected species, the number of adults varies little from year to year in response to environmental variables. Instead, these species respond to changes in annual carrying capacity by reductions in birth rates and increases in cub and subadult mortality rates.

The mortality rate of subadults was found to be 36.8% in northwestern Montana (Thier 1990). High mortality of subadult males (less than 5 years of age) is associated with dispersal. Subadult females typically stay within or near the home of their mother while subadult males disperse into unfamiliar habitats. This pattern for dispersal may avoid inbreeding. Adult male black bears have been reported to kill subadult males as they disperse (Jonkel and Cowan 1971, Poelker and Hartwell 1973, Kemp 1976, Rogers 1987). Several studies have suggested that aggression by adult male black bears may be a factor in population regulation through death of subadults directly or through dispersal-related mortality (Beecham 1980a, Hugie 1982, Young and Ruff 1982, and Rogers 1983). However, the evidence for this is still primarily conjectural (Garshelis 1994) Female black bears have been known to kill other bears as well as males (Garshelis 1994). Bunnel and Tait (1981) hypothesize that older males provide an ideal regulatory mechanism because they are subject to very few forms of mortality. Identification of density-dependent effects in bears is difficult because of multiple-year reproduction schedules, low reproduction potential, physiological and behavioral plasticity, long generation time, large home range, low population densities, and high research costs (Taylor 1994). Taylor agreed with Garshelis (1994) that evidence for any general or specific form of density effects for any population of bears is inconclusive.

Young males have lower survival rates than young females (Jonkel and Cowan 1971, Koch 1983, Rogers 1987, Elowe and Dodge 1989). Young males tend to disperse farther from their mother's home range and, thus, have a significantly higher chance of encountering older male bears, hunters, and other factors that increase mortality rates. Malnutrition, thought to be most common in subadults when they disperse, also contributes to natural mortality. Jonkel and Cowan (1971), Kemp (1976), and Rogers (1977) documented malnutrition in black bear populations.

Researchers have estimated total adult mortality to be between 15% and 27% annually (Erickson et al. 1964, Poelker and Hartwell 1973, DuBrock 1980, Lindzey and Meslow 1980, Kohn 1982, Thier 1990). Thier (1990) recorded an annual adult mortality rate of 25%, slightly higher for males (25.1%) than for females (22.7%). The higher mortality rate of males has been attributed to their larger home range size (Bunnel and Tait 1985) and their less wary nature (Beecham 1980a). Simmons and Stewart (1989) reported an average mortality rate of 16% for marked black bears, while Jonkel and Cowan (1971) estimated natural mortality rates for adults at 14%.

Black bears are subject to predation by grizzly bears (Ross et al. 1988) and by wolves (Rogers and Mech 1981, Rogers 1987, Ross et al. 1988). Black bear mortality attributed to grizzly bears was report by Jonkel and Cowan (1971). Aune and Kasworm (1989) found hair from black bears in grizzly scats.

Black bear have been reported to live to 32 years in the wild, based on estimates from dental cementum annuli. The oldest black bears reported in the Montana harvest were a 30-year old male and a 29-year old female. Bunnel and Tait (1985) suggest that at least 50% of the mortality experienced by North American bear populations can be attributed to sport hunting of black bear. Several authors have stated that hunting harvest limits population size (DuBrock 1980, Hugie 1982, Bunnel and Tait 1985, Thier 1990).

Effects of Recreation on Black Bears

Effects of Sport Hunting on Black Bears - Sport hunting of black bear populations, as well as other wildlife populations is based on the concept of "sustained yield." The principle of sustained-yield management is that wildlife populations produce an annual increment of animals that can be removed without causing the population to decline. The size of the annual surplus varies by species (factors such as proportion of females in the population and average litter size) and according to local conditions (factors such as habitat quality and population density). Theoretically, annual hunting harvest compensates (via reproduction and recruitment rates) for natural mortality. To a point, hunting mortality is expected to be compensated for by a corresponding decline in natural mortality (Kemp 1972, 1976; Bunnel and Tait 1981; Miller 1990b; Schwartz and Franzmann 1991). However, Taylor (1994) cautions that "managers should assume that no increases in reproduction and no decreases in rates of natural mortality will result from reductions in population numbers, at least until such time that density-dependent mechanisms of population regulation in bears have been documented." In Montana, black bear hunting is managed according to large land areas called Bear Management Units (BMUs), which generally provide for separate spring and fall hunting periods. Baiting bears or hunting with hounds is not allowed. An average of 1,235 bears are harvested per year (1993-1995) with approximately 46% taken during the spring season.

Bear densities are partially limited by food availability (Rogers 1976, Graber 1982, Grenfell and Brody 1983, LeCount 1987, Elowe and Dodge 1989). Reproductive rates of bear populations, however, are largely a function of nutrition rather than bear densities (Jonkel and Cowan 1971, Rogers 1976, Beecham and Reynolds 1977, LeCount 1977, Bunnel and Tait 1981, and Elowe and Dodge 1989). Black bears, then, cannot be expected to respond to heavy hunting harvest with compensatory reproductive responses such as larger litter size or younger breeding age (both of which are characteristic of species with density-dependent reproductive strategies). In fact, high adult mortality may result in a younger age population and lower productivity (Beecham and Zager 1992). It follows that there is a "threshold of mortality," below which the reproductive capacity of a bear population can compensate for hunting mortality. If total mortality exceeds the threshold, hunting mortality will, in effect, become additive (to natural mortality rates) rather than compensatory (Miller 1990b). Examples of this threshold have been described by LeCount (1986) and Elowe and Dodge (1989).

Vulnerability of black bear populations to hunting harvest varies according to habitat and levels of access. Bears are least vulnerable where cover is dense and extensive and most vulnerable in areas with many roads and limited amount of escape habitat. Vulnerability of individual bears to hunting harvest is influenced by sex and age. Subadult males are typically the most vulnerable because they are dispersing into new habitats. Adult males are also vulnerable because they have the largest home ranges and may be less timid about human contact than adult females. Also, males emerge from dens earlier and enter dens later than females and are, correspondingly, more available to hunters. Consequently, the adult male segment of the population is the first to be reduced through hunter harvest. Females are less vulnerable, especially those with cubs. Therefore, an increasing proportion of females in the harvest is an indicator of increasing harvest rate. This indicator can be confounded by changes in hunting regulations, hunting technology, or seasons that shift the relative vulnerability of each sex to hunter harvest.

Most black bear management programs include safeguards to assure moderate harvest of females (Garshelis 1994; T. Beck, Colorado Division of Wildlife, Department of Natural Resources, personal communication; J. Beecham, Idaho Fish and Game Department, Boise, personal communication; and A. LeCount, Arizona Game and Fish Department, Phoenix, personal communication). This strategy is intended to keep hunting harvest below the threshold of mortality, maintaining harvest rates within the reproductive capacity of the population to compensate for hunting mortality. Managed below this threshold, bear populations can sustain continued, regulated hunting harvest (Kemp 1972, Wakefield 1972, LeCount 1977, Poelker and Parsons 1977, Reynolds and Beecham 1980, Servheen 1989).

Effects of Roads and Trails - Limited research is available concerning the effects of recreational use of roads and trails on black bears. However, Young and Beecham (1986) and Beecham and Rohlman (1994) report that Idaho black bears may react to increases in road densities by shifting the location of their home ranges to areas of lower road densities. Female black bears avoided roadsides, while males used roadsides in proportion to their availability.

This was probably due to differences in mobility. Kasworm and Manley (1990) found that black bears in northwestern Montana avoided habitat within 274 m of open roads. Trails displaced black bears less than open roads. Overall, both sexes prefer to stay at least 50 yards from roads, except when feeding (Beecham and Rohlman 1994).

Brody and Pelton (1989) found that black bears rarely crossed an interstate highway in a North Carolina study area. Bears crossed low-traffic volume roads more frequently than roads of higher traffic volume. The frequency of road crossings by black bears did not vary by sex, age, or season. Bears did not restrict their movements in reaction to road density within established home ranges.

Tietje and Ruff (1980) reported that the numbers and sex and age structure of bear cohorts before and during oil and gas development in Alberta (during 1976 and 1977) were not significantly different. In general, activity patterns and movements remained unchanged. The data suggests that in the absence of appropriate management strategies, secondary impacts of *in situ* oil extraction, such as new roads, increased bear hunting (legal and illegal), and human habitation may be of greater consequence than the primary impacts of habitat alteration and loss.

Reducing the number of timber access roads is a means of influencing bear harvests and mitigating the effects of timber harvest (Lindzey and Meslow 1977, Irwin and Hammond 1985, Lindzey et al. 1986, Unsworth et al. 1989, Beecham and Rohlman 1994, Mace and Waller 1997).

Effects of Human Disturbance in Areas of High-use by Bears and Humans - Conflicts between people and black bears in national parks and other high-density human recreation areas are a source of concern for managers. Most human-bear conflicts in Yellowstone National Park have involved food-conditioned bears seeking human foods or bears seeking natural foods within developed areas and along roadsides (Gunther 1994). Problems in Yosemite National Park prompted officials to take strict measures to protect both black bears and human visitors. Thompson and McCurdy (1995) recommend larger bear-proof food boxes, increased enforcement, increased frequency of garbage pick-up, better information and education, and more staff to prevent continued alteration of bears from natural conditions. Big Bend National Park officials recently closed campgrounds due to bear-human conflicts (Skiles 1995).

During the fall, berries are a staple in the diet of black bears. Berries provide high energy and energetically efficient conversion to fat which is needed for successful hibernation and reproduction. Without adequate berry crops in the fall, energy reserves may be inadequate to support both life and parturition during hibernation and, consequently, incipient pregnancies will be physiologically halted. The abundance of berries available to bears during the fall is highly variable between years and places because of spatial and temporal differences in weather, which influence berry productivity. Although specific data are lacking, there is widespread speculation that recreational berry picking, especially during years when berries are sparse, may adversely influence the bears' energy balance during this key fall period of intensive berry use by bears. Humans, like bears, are able to seek out and find the best spots for berry picking, and human presence in these areas may displace bears and human berry picking may reduce abundance of berries available to bears. The importance of berries to bears is illustrated by increased movements and nuisance problems with hungry bears during years when huckleberries and blueberries are sparse. Although specific data demonstrating this are lacking, human berry picking activities may simulate and, in effect, increase the frequency and severity of naturally occurring reductions in berry crops.

Effects of "Country Living" - People often relocate their place of residence to be in or near areas where they recreate. Recreational country living, that is, homes and associated activities, such as dogs, pet foods, garbage, gardens, orchards, ornamental fruit trees, and bird feeders can turn wild bears into nuisance bears. While black bears can accommodate some increased human activities within their home range, people generally will not allow bears to remain once they become habituated to human foods. It then becomes the responsibility of the state wildlife agency to remove "problem" bears. Because relocating habituated bears is rarely successful, the bear is usually killed. The increase in subdivision development in bear habitat in recent years has resulted in an increase in bear complaints in areas where agricultural operations once existed. Given the levels of subdivision development in bear habitat, the situation will worsen.

Effects of Winter Disturbance - Dens are selected away from possible disturbance (Tietje and Ruff 1980), and studies show that bears readily abandon den sites following human disturbance (Lindzey and Meslow 1977, Hamilton and Marchington 1980, LeCount 1983, Manville 1983). Three of 5 dens were abandoned in southwestern Montana following human disturbance (Mack 1990). Carney (1985) reports 3 of 14 females abandoned cubs after researchers disturbed them in Shenandoah National Park. Tietje and Ruff (1980) suggest that den disturbance and subsequent abandonment could adversely affect bears by contributing to excessive overwinter weight loss. Bears may minimize fat loss by denning in more remote, undisturbed areas. Tietje and Ruff (1980) found that following den abandonment, bears lost 25% of their body weight compared to a 16% loss for bears that did not abandon dens. Nursing bears or den abandonment accounted for an additional 9% overwinter weight loss.

Tyers and Reinhart (1999) suggests 3 stages in the annual cycle of grizzly bears when they are vulnerable to impacts of winter recreation: pre-denning, denning, and post-den emergence. Reynolds et al. (1984) monitored heart rates of grizzly bears subjected to aircraft and seismic activity. Sounds of seismic vehicles passing within 5/8 mile from dens caused an elevated heart rate but not den abandonment. Reynolds and Hechtel (1980) speculated that disturbance of a female with newborn cubs from noise near the den could have negative consequences. Den abandonment and accelerated starvation can be initiated by human disturbance (Watts and Jonkel 1989).

Management can be designed to minimize impacts to bears during pre- and post-denning periods for public-use areas such as campgrounds, hiking and snowmobile trails, ski areas, and visitor centers. Potential for bear-human conflicts are high if recreation is allowed during these periods, especially when food sources are nearby (Mattson et al. 1992).

Conclusions

Bears and people have coexisted in North American for thousands of years. Black bears figured prominently in the rites and traditions of native peoples, who both hunted and revered bears. In recent history, both black bears and grizzly bears were viewed with fear and intolerance – as dangerous predators, competitors, and pests (Yodzis and Kolenosky 1986, Miller 1990b). Efforts to exterminate bears through trapping, unrestricted killing, and government-sponsored bounty programs reduced bear populations substantially, especially in the southern and southeastern U.S. (Aderhold 1984, Garshelis 1990). In recent decades, a prevailing utilitarian, exploitative attitude toward black bears has given way to one of greater understanding and appreciation (Kellert and Westervelt 1982). Today, black bears are valued as an important component of the ecosystem and admired by those who seek to watch, photograph, and hunt them.

Impacts of recreating humans on black bears are not well understood. Separating effects of hunting from other forms of recreation is complicated, and it appears that most research on effects of roads and trails (for example) deals mostly with black bear mortality due to increased access to bear habitats. Black bears, however, appear better able to tolerate human use of roads and trails than grizzlies.

Management of black bears requires knowledge and information from a variety of sources. Bears do not frequent habitats where they are easily counted like elk and deer, thus, population parameters are not easily obtained. Population dynamics are also poorly understood in relation to other big game species. For instance, parameters that indicate population trend in other species may only be obvious in bears after the population is depleted. Additionally, shifts in age classes of bears in the harvest may not indicate trend unless natality, mortality, immigration, and emigration are documented through intensive research. Because black bears, especially males, can be highly mobile, population boundaries may not actually exist if suitable habitat exists to allow gene flow along a continuum.

Weather affects food supplies, which in turn, affects cub production and survival on an annual basis. Because bears are particularly long-lived, produce cubs after age 6 or 7 (and then perhaps only every third year), population changes are often difficult to detect, even in a span of several years. Only long-term research can detect such changes. Long-term research on black bear population assessment techniques, impacts of harvest, and conflict avoidance are needed.

Guidelines/Recommendations

Literature-supported guidelines and committee recommendations for minimizing or mitigating effects of human disturbance on black bears, are as follows:

1. Control access on public land secondary roads as a means of influencing bear harvests and mitigating the effects of

road construction (Lindzey and Meslow 1977b, Irwin and Hammond 1985, Lindzey et al. 1986, Unsworth et al. 1989, Beecham and Rohlman 1994, Mace and Waller 1997).
2. Develop hunting management guidelines to ensure healthy black bear populations and habitats (MFWP 1994). Population assessment techniques for black bears are expensive and imprecise and, correspondingly, not frequently employed, therefore, it is recommended that conservative bear harvest strategies be implemented for bear management units.
3. Provide intensive education about living in bear country, proper techniques for minimizing bear-human conflicts, the negative effects of habituating bears to human foods, and the importance of keeping bears wild. People living in bear habitat must understand that habituated bears often will be destroyed when nuisance situations occur.
4. Pursue land-management agreements and joint-venture projects that block up critical bear habitat, including movement corridors between populations. This would involve public-private cooperation in forming land trusts, easements, trades, acquisitions, and management-guideline agreements.
5. Encourage public participation in land-use planning legislation and promote efforts to avoid development in critical wildlife habitats.
6. Include black bears in local and regional habitat conservation efforts that emphasize other big game species.
7. Designate snowmobile-use areas so that they avoid black bear denning habitat prior to, during, and after denning. Other recreational use should be restricted in known use areas during: the pre-denning period, which occurs from 15 October to 1 December; the winter denning period; and the post-denning period, the beginning of which ranges from 15 March for some males to 30 April for some females, and extends to approximately 15 May .
8. Encourage limitation of human berry picking activities during years when, and in geographic areas where natural depletions of berry abundance occur. Expand public information efforts to include television and radio notices explaining why people should avoid picking berries in scarce berry years.

Management guidelines for recreational activities, including roads and trails, in bear habitat are difficult to find in current literature. Information presented above is the basis for the following recommendations:
1. Winter activities, such as snowmobiling and skiing, should not be allowed within 1 km of known den sites.
2. If possible, avoid line-of-sight activities around den sites. Design trails so that some topographical barrier, (i.e., ridge or hill) separates activities from den sites.
3. Implement road closures to prevent overharvest of bears in vulnerable habitats or allow access for limited periods.
4. Prevent human-bear conflicts by using bear-proof food storage boxes in bear habitat, especially campgrounds and national parks.
5. Err on the side of wildlife if specific guidance is unavailable regarding recreational impacts; we recommend monitoring or research to obtain the desired information.

Information Needs

1. Initiate long-term research to assess population and habitat parameters and the effects of increasing human interaction with bears.
2. Develop and apply habitat models to identify prime denning habitat and then manage human seasonal activity in these areas to avoid and minimize impacts near and during the bear denning season.
3. Determine whether recreational activities are influencing food or other life-cycle necessities for black bears during seasons of the year other than denning.
4. Evaluate the effectiveness and comparative results of spring and fall bear hunting seasons with the intent of improving bear management and monitoring criteria where possible. Evaluate the possible consequences of bear harvest on sex and age through varying the opening and/or closing dates of each season.

GRIZZLY BEAR

Introduction

Grizzly bears (*Ursus arctos*) are wide-ranging, adaptable mammals considered to be opportunistic omnivores. Historically, they were widely distributed throughout the northern hemisphere, occupying a broad range of habitats from true desert to coastal rainforest to arctic tundra. Grizzly bear populations declined across their range as human expansion consumed space and resources that grizzlies require, because they were not tolerated by humans. Currently, grizzly bears are restricted to the most isolated and mountainous portions of their former range.

In North America, prior to European settlement, grizzly bears were continuously distributed from the 95th meridian westward to the Pacific Coast and from northern Mexico to the Arctic Circle (Servheen 1998). Beginning in the mid-1800s, settlers began moving into grizzly bear habitat west of the 95th meridian. Grizzly bears were perceived as a threat and indiscriminately killed through the mid-1900s. By 1950, grizzly bears were extirpated from all but a few isolated and mountainous locations in the United States and were restricted to Alaska and the mountainous and northern portions of western Canada. Changes in public perceptions of carnivores and their role in ecosystems combined with concern for the welfare of the grizzly bear, resulted in its listing as threatened under the ESA in 1975.

Currently, the greatest numbers of grizzly bears, perhaps close to historical numbers, occur in Alaska (31,000, Miller 1993) and the Canadian provinces of British Columbia, Northwest Territories and Yukon Territory (25,000 estimated, Banci et al. 1994). Smaller, fragmented populations occur in the Canadian province of Alberta and the states of Idaho, Montana, Wyoming, and Washington. The USFWS recognizes 5 grizzly bear recovery areas: the northern Continental Divide ecosystem (NCDE) in Montana, the Selkirk-Cabinet-Yaak ecosystem, and the Bitterroot ecosystem in Montana and Idaho, the Northern Cascades ecosystem in Washington, and the Yellowstone ecosystem in Montana, Idaho, and Wyoming. The Northern Cascades, Selkirk-Cabinet-Yaak, and NCDE populations are contiguous with grizzly populations in British Columbia and Alberta (IGBC 1987). Grizzly bears are currently hunted legally in Alaska and Canada but not in the lower 48 United States.

Recreational activity in occupied grizzly bear habitat may, in some cases, diminish the value of habitat for grizzly bears through modification or displacement. Black bear hunters sometimes misidentify and shoot grizzly bears, which adds mortalities that impede recovery efforts. Understanding the relationships between grizzly bear ecology and potential recreational activities can help managers prevent adverse effects on grizzly bear populations and promote grizzly bear recovery.

Life History and Habitat Requirements

Habitat Use - In most areas, grizzly bears have specific movement patterns related to the availability of vegetal and animal food sources. Elevation, climate, and topography interact with vegetation to influence grizzly bear distribution. In many cases grizzly bear movement patterns can be predicted, however, they may be modified during the breeding season by the reproductive status of females, the distribution of adult males, and human use and development patterns. Waller and Mace (1997) reported seasonal elevational movement patterns of grizzly bears in northwestern Montana. Grizzly bears denned at high elevations, moved to lower elevations during spring to obtain green vegetation, then tracked plant phenology to high elevations during summer. High elevations were used during fall but with more variation. They cited researchers from Yellowstone National Park (Mealey 1980), Glacier National Park (Martinka 1972), Jasper National Park, Canada (Mundy and Flook 1973), Mission Mountains, Montana (Servheen 1981), and Denali National Park (Darling 1987) as reporting similar elevational use patterns.

Grizzly bears exhibiting different patterns of elevational use were reported by Servheen (1983) for the Mission Mountains, Montana; McLellan (1989) for the North Fork Flathead River, British Columbia; Hamer and Herrero (1987) for the Rocky Mountain East Front, Alberta; and Aune and Kasworm (1989) for the Rocky Mountain East Front, Montana. Although these researchers identified bears that followed patterns similar to those reported above, they also reported on bears that tended to move from denning areas to lower elevations and then remain at lower elevations through the summer and fall seasons to exploit available food resources. McLellan (1989) and Aune and Kasworm (1989) also reported on bears that tended to remain at higher elevations throughout most of the year.

Grizzly bear habitat use and food habits differ among the 4 currently occupied recovery areas. The Yellowstone ecosystem and the eastern half of the NCDE are more xeric than the other recovery areas. Thus, these areas differ in the primary foods consumed by grizzly bears and in patterns of grizzly bear habitat use.

In the Yellowstone ecosystem, as described by Knight et al. (1984) and in IGBC (1987), grizzly bears generally preferred non-forested cover types during spring and summer seasons. Low-elevation Douglas fir (*Pseudotsuga menziesii*) cover types were markedly preferred during spring. High-elevation whitebark pine (*Pinus albicaulis*) sites were preferred during fall and to a lesser extent during summer. Grizzly bear use of lodgepole (*Pinus contorta*) types was variable, with climax sites generally avoided. Use of spruce (*Picea* spp.)/Douglas-fir types was typically neutral or preferred.

Differences in use of successional stages were most pronounced in low-elevation Douglas-fir types and high elevation whitebark pine types. Bear use was positively associated with older aged forest communities. Reasons identified for this were the distribution of ungulates and succulent plants in the Douglas-fir and climax lodgepole pine types and the need for 100+ year-old whitebark pine trees for pine nut production.

Cover type diversity did not influence habitat selection during any season in any area. Grizzly bears generally favored areas with relatively high edge density, most notably forest-nonforest ecotones. Use of forest-nonforest ecotones was associated with ungulate winter ranges, high rodent densities, and security. This general use pattern was also reported by Graham (1978), Blanchard (1983), and Brannon (1984).

Grizzly bear habitat use in the western portion of the NCDE has been described by several researchers, but most extensively in the northern Swan Mountains by Waller and Mace (1997). Here, both sexes used avalanche chutes more than other cover type during all seasons, while, during summer, females also selected for slab rock and timber harvest units. Grassland cover types were selected at a moderate level during all seasons. Forest was the least selected cover type by females during spring and by males and females during summer and fall, although forest represented 62% of the study area and was the cover type where about 50% of radio relocations were recorded. Many, but not all, avalanche chutes contain preferred herbaceous forage species, visual security, and temperature moderation within dense alder stands (Mace and Bissell 1985). As grizzly bears began feeding on the fruits of shrubs during summer and fall, their use of timber harvest units and natural shrub fields increased. These cover types are associated with high fruit production (Martin 1979, Zager 1980, Waller 1992). In addition, bears were reported to extensively use floodplain habitats during all seasons in the North Fork of the Flathead River Valley (McLellan 1989) and the grassland-forest interface in the Mission Valley, feeding on wild and domestic fruit (Servheen and Klaver 1983; A. Soukkala, Confederated Salish and Kootenai Tribe, personal communication).
Grizzly bear habitat use in the eastern portion of the NCDE was best described by Aune and Kasworm (1989). They described different seasonal use patterns between the more mesic northern portions of the Rocky Mountain Front and the dryer habitats of the southern Rocky Mountain Front. Spring bear use was concentrated in lowland riparian and grassland habitats in the drier Teton River area, while bears in more mesic areas were using sidehill parks, avalanche chutes, aspen stands, and riparian shrub sites. During summer, bears in drier habitats excavated roots in rock/talus/scree sites and sought berries in lowland aspen and riparian shrub communities, while bears in more mesic areas shifted into mountainous berry-producing open and timbered shrub fields. By fall, most bear use had shifted into timbered habitats. Bears in drier habitats searched for pine nuts in whitebark pine stands and for berries and roots in lowland aspen and riparian shrub communities. Use of timbered sites by grizzly bears on the Rocky Mountain East Front was high for all seasons.

Food Habits - The historic distribution of grizzly bears suggests a species capable of utilizing a broad array of habitats and the foods they produce. The IGBC (1987) reported that the digestive system of the grizzly bear is similar to other carnivores but has adaptations, including increased intestine length and crushing molars, to aid in digestion of a diet having large quantities of vegetable matter. These digestion system adaptations do not include multiple stomachs or a caecum, and grizzlies are unable to digest cellulose. Therefore, bears require animal or vegetable matter that is highly digestible and high in starch, protein, and stored fat (Stebler 1972, Mealey 1975, Hamer et al. 1977 in USFWS 1993).

The IGBC (1987) reported the primary foods utilized by grizzlies in the NCDE and Selkirks (northern area) and Yellowstone (southern area) as follows:

Vegetation: During spring and fall seasons, bears in both northern and southern areas tended to utilize plant roots, corms, and tubers, with this use continuing during summer in the southern area. The vegetative parts of *Equisetum* spp., grasses, *Carex* spp., clover, and dandelions were utilized in both areas during spring, summer, and fall, while *Heracleum* and *Ligusticum* were utilized only in northern areas. Only *Lomatium* corms were excavated in both areas, while *Claytonia* and *Erythronium* corms were excavated only in the northern area and only *Polygonum* in the southern area.

Fruits and Nuts: During summer and fall, fruits from a large number of shrub species were the primary forage for bears in the northern area but not for bears in the southern area. *Vaccinium* and *Sheperdia* were highly utilized in northern areas, with *Prunus*, *Sorbus*, *Crataegus*, *Amelanchier*, and domestic fruits used in more localized areas or less frequently. Pine nuts, from *Pinus albicaulis*, were identified as a food item during fall in both the northern and southern areas, but only in the southern area during spring. Mattson et al. (1992), reported pine nuts as a primary forage item in the southern area.

Animal Matter: Rodents were utilized during summer and fall in the northern area and during all seasons in the southern area. Wild ungulates were utilized during all seasons in the southern area, while trout was only utilized during summer. Domestic livestock was utilized during all seasons in the northern area, reported for the area east of the Continental Divide (Madel 1986, Aune and Kasworm 1989), with earthworms utilized during fall in the Selkirks. Insects were utilized during all seasons in the northern and southern areas, but very different insect groups and sites were involved between seasons. Spring and summer season use was associated with low elevation use of ants and grubs found in decaying wood and under rocks, while other summer use was associated with high elevation rock/talus/scree sites where army cutworm moths concentrate in large numbers during July and August (Klaver et al. 1985, French et al. 1994). In general, grizzly bears in the Yellowstone ecosystem and along the Rocky Mountain East Front consume more animal matter than grizzly bears in other areas (Jacoby et al. 1999).

Denning - The IGBC (1987) summarized denning habitat use and dates of entry and emergence for a number of studies from Yellowstone National Park (Craighead and Craighead 1969, 1972; Knight et al. 1978; Judd et al. 1986), Rocky Mountain Front (Aune et al. 1986), Glacier National Park (Shaffer 1971), Mission Mountains, Montana (Servheen 1981), Selkirk Mountains, Idaho (Almack 1985), southern Rocky Mountains, Canada (Wielgus 1986), Banff National Park, Canada (Hamer and Herrero 1983), and Jasper National Park, Canada (Russell et al. 1979).

Dens constructed by bears occurred slightly more often on northerly aspects (approximately 60%) than on southerly aspects, except in the Missions Mountains (where use of aspects was approximately equal) and Jasper National Park (where southerly aspects represented 70% of den sites). Den sites occurred at high elevations, with the range of mean elevations being 1,896-2,470 m, with most higher than 2,000 m. Den sites tended to occur most often within subalpine forest and non-forest communities and on steep slopes of 30-55 degrees. Den entry generally occurred during late October through mid-November for all areas, with den emergence occurring during mid-March through early May. Pre-hibernation lethargy may begin a number of weeks prior to final den entry (Craighead and Craighead 1972, Servheen and Klaver 1983 in USFWS 1993).

Mace and Waller (1997) provided additional insight into den use by various sex and age classes of bears in the northern Swan Mountains, Montana. Den site selection was similar for all age and sex classes and only once was a den used in more than one season, although the same general location was frequently used. On average, females entered dens earlier (4 days) and left dens later (13 days) than males. Females with cubs entered dens earlier and left dens later than other classes of bears (females with cubs = 177 denning days and adult males = 148 denning days). Bears remained in the vicinity of the den an average of 11 days prior to final entry and an average of 15 days after den emergence.

Reproduction - Female age of first reproduction and litter size varies and may be related to nutritional condition (Herrero 1978, Russell et al. 1979). Age of females at first parturition varied from 4.5 to 9.5 years for grizzly bears across North America, with litters of 2 cubs and a breeding interval of 3 years most common in the lower 48 states and southern Canada (IGBC 1987). Breeding season appears to occur during late May through mid-July (USFWS 1993, Mace and Waller 1997), with cubs born in dens in January-February after a 229-266 day gestation period (Banfield 1974). According to the USFWS (1993), "Grizzly bears have one of the lowest reproductive rates among terrestrial mammals, resulting primarily from the late age of first reproduction, small litter size, and the long interval between litters."

Mortality - Mortality may occur naturally due to disease, parasites, predation/cannibalism, malnutrition, and accidents, but the rate or effect of this natural mortality on grizzly bear populations is not well known. The IGBC (1987), Miller (1990a), USFWS (1993), and McLellan (1994) and, identified these mortality factors and implied that malnutrition in cubs and, perhaps yearlings, and conspecific predation by adult bears may occur at a level sufficient to influence populations, but that other factors appeared to be a minor influence on population change.

Human-caused mortality is a continuing concern of grizzly bear managers and has been the primary cause of the loss of grizzly bears from much of their historic range (Storer and Tevis 1955; Brown 1985; Koford 1968, 1969; and Leopold 1967 in IGBC 1987). Human-caused mortality continues to affect grizzly bear populations in the lower 48 states. Harris (1985) suggests that grizzly bear populations can accommodate a maximum 6% human-caused mortality rate without decline. The USFWS (1993) identified human-caused mortality categories including: (1) direct confrontations with recreation users, (2) attraction of grizzly bears to human and livestock foods and garbage, (3) association with livestock production and protection, (4) use of bear habitat for human development or uses that decrease habitat quality or availability, and (5) legal and illegal hunting. A mortality category that has affected bear populations in the NCDE is accidental collisions between bears and autos or trains (NCDE mortality report 1995).

Grizzly bear recovery plans (USFWS 1982, 1993) identified general criteria for the reduction of human-caused mortalities, while the Interagency grizzly bear guidelines (IGBC 1986) outlined specific actions to reduce grizzly bear mortality risk. Annual reports of IGBC Ecosystem Subcommittees (YGBES, NCDGBES, and Selkirk and Cabinet/Yaak Subcommittee annual reports 1980s-1990s) and Montana Fish, Wildlife and Parks environmental impact statement for the grizzly bear in northwestern Montana (Dood et al. 1986) document efforts and results of implemented actions. A full list of actions is available in the referenced (unpublished) documents, but major efforts have involved the following: (1) reduction of sheep grazing in grizzly bear habitat, (2) implementation of bear resistant garbage storage, 3) redistribution of livestock remains out of “boneyards” near homes, (4) providing grizzly bear management specialists (MFWP, Wyoming Game and Fish, and Confederated Salish and Kootenai, and Blackfeet tribes) to deal with private land and grizzly bear issues, (5) food storage requirements for people using national park, U.S. forest service, and Indian reservation lands, (6) use of aversive conditioning methods to modify bear behavior, (7) restriction and reduction of motorized access to public and some private timber company lands, (8) better grain spill clean-up by railroad companies, (9) education of hunters in the identification of black and grizzly bears, (10) interest by local communities in the development and implementation of private land bear management considerations, (11) elimination/redistribution of livestock and game carcasses near roads and trails, (12) damage payment by conservation groups to ranchers whose livestock are killed by bears, and (13) development of "pepper spray" bear deterrents.

Mace and Waller (1998) presented mortality data for the grizzly bear population in the northern Swan Mountains, Montana, for the period 1987-97, with 35 mortalities reported. Five (14%) mortalities were categorized as unknown, 10 (29%) natural, 20 (67%) human-caused, and 1 (3%) research related. All human-caused mortality occurred in either the spring or fall periods. The categories of human-caused mortality included management removal (6, or 17%), mistaken identification by black bear hunters (6, or 17%), malicious (3, or 9%), self defense (3, or 9%), legal hunt (1, or 3%), and research (1, or 3%). A mortality report for the NCDE (NCDGBES 1995) covering the period 1984-93 included similar categories and values, but also identified bear mortalities associated with livestock and trains as major categories. The report also identified the increased role that management removals had later compared to earlier in the period.

Mace and Waller (1998) also identified the type of environment where bear mortalities occurred. Out of 19 human-caused mortalities, (excluding 1 research mortality), 5 (26%) died outside of the study area in the Bob Marshall Wilderness, 2 (11%) died in the "core" study area, (a multiple-use U.S. Forest Service area with public road access), and 12 (63%) died or were removed in the "rural" area (an area that included human dwellings and private lands).

All identified management activities address a specific mortality element. The Yellowstone grizzly bear population was reported to be increasing at a 3-4% annual rate for the period after the mid-1980s (Eberhardt and Knight 1996). Estimates for population trend in the NCDE were made for some areas, but data were too localized to allow for an ecosystem-wide estimate. The upper North Fork Flathead River area was estimated to be increasing at an annual rate of 6% for the period 1978-1994 (Servheen et al. 1994). The population segment occupying the northern end of the Swan Mountain Range was depicted as "tenuously stable" (Mace and Waller 1998). No estimate for other areas within the NCDE or other grizzly bear ecosystems is currently available.

Recreation

Although the original ESA listing of the grizzly bear in 1975 focused primarily upon direct mortality, later recovery efforts have increasingly identified habitat use, quality, and availability as important elements of grizzly bear management (USFWS 1982, 1993). The importance of human activity as factors that may displace bears from important habitats or increase mortality risk began to assume prominence as national forest plans were developed in the late 1970s through the mid-1980s. These plans outlined resource objectives and management standards and guidelines for national forests for a 10-15 year period. Activity effects and management considerations were summarized in the Yellowstone grizzly bear guidelines (Mealy 1979) and were later modified to become the Interagency Grizzly Bear guidelines (IGBC 1986). The IGBC grizzly bear guidelines established a framework in which management agencies would maintain and improve habitat, minimize grizzly-human conflict potential, and resolve grizzly-human conflicts (IGBC 1986). Since the publication of the IGBC guidelines, the human populations of counties within and adjacent to grizzly bear recovery areas have grown substantially, accompanied by increased recreation on public lands.

Motorized Recreation - During the 1950s, 60s, and 70s it was the general policy of land-management agencies to establish road systems on public lands not designated as wilderness. This road system provided access to timber and mineral resources and provided public access. During the past 20 years, there have been dramatic technological improvements to off-road vehicles (ORVs). Four-wheel drive vehicles are now common in most urban, suburban, and rural areas of the U.S.. All-terrain vehicles (ATVs), trail bikes, and snowmobiles have become easier to use, more reliable, and affordable to a large segment of the population inhabiting the northern Rockies. The result of the proliferation of these types of vehicles has greatly increased ORV use on public lands. As public use of forest road systems increased, so did agency concern for the effects of this use on resident grizzly bears.

There have been numerous studies on the effects of roads on grizzly bears, and all have shown negative impacts (Elgmork 1978, Zager et al. 1983, Archibald et al. 1987, Mattson et al. 1987, McLellan and Shackleton 1988, Kasworm and Manley 1990). Further research concerning the level of roading or road use required to alter bear habitat use was facilitated by the development of computer geographic information systems (GIS) that allowed precise estimates of road density for any area of interest. Mattson recommended maximum road densities of 0.6 mi/mi_, with 0.26 mi/mi_ over the lifetime home range to provide for "wary" female bears in the Yellowstone area (D. Mattson, former Interagency Grizzly Bear Study Team, 1992 unpublished report). In preliminary reports, Manley and Mace (1992) and Mace et al. (1992) used univariate analysis and reported that bear use was significantly less than expected where open road density was >1 mi./mi^2 or where total road density was >2 mi/mi^2.

Later multivariate analysis by Mace et al. (1996) presented a more complex relationship between roads, habitat, and grizzly bear use. Seasonal home ranges of 14 adult and subadult female bears were used to analyze habitat selection in relation to roads at 3 hierarchical levels. At the second order of selection, where bear home ranges occurred or did not occur, relative probability of occurrence was zero for private lands in the Flathead Valley for all combinations of habitat and road variables. Relative probability of occurrence on U.S. Forest Service multiple-use lands was negatively associated with increasing values of road density and declined to zero as road densities approached 6.0 km/km^2.

At the third order of selection, habitat selection within home range areas showing changes in habitat use due to roads differed by season and among individual bears. Probability of occurrence generally decreased as road density increased, but certain individuals had greater tolerance for high road densities. Also, tolerance for high road densities was greater in highly preferred habitats.

At the fourth order of selection, within a 0.5 km buffer around roads, bear responses differed by season and traffic volume. Few home ranges contained roads having traffic volumes of >60 vehicles/day, and most bears avoided roads having >10 vehicles/day during all seasons. Most individual bears reacted either negatively or neutrally towards roads having 1-10 and <1 vehicles/day during all seasons.

Winter motorized recreation can be associated with defined routes or dispersed over the landscape. Mace and Waller (1997) reported no den abandonment by grizzly bears in the northern Swan Range, Montana, although they routinely observed snowmobile activity within 2 km of grizzly bear dens. The den sites were usually located on steep timbered slopes that the researchers believed were nearly impossible for snowmobiles to traverse. However, Harding and Nagy (1980) reported den abandonment due to hydrocarbon exploration activities in Northwest Territories, Canada. Reynolds et al. (1986) reported on the responses of denning grizzly bears in Alaska to winter seismic surveys, including snow machines, drill rigs, aircraft, and detonation of dynamite. Detonations within 0.8-1.2 mi. of denning bears did not cause abandonment, but movements within dens were noted in some cases. A female with yearlings did not abandon her den when vehicle use was occurring within 325 ft. They reported probable den abandonment by an unmarked bear when seismic activity was within 650 ft of the den. When vehicles operated within approximately 3,300 ft of denned bears, their heart rates were elevated compared to undisturbed conditions. The heart rate of denned bears increased in response to overflights by small aircraft near the time of den emergence but not at other times.

Although abandonment of dens was not reported as a frequent result of the winter human uses described, Reynolds and Hechtel (1980), Watts and Jonkel (1989), and Mace and Waller (1997) expressed concern that physiological stresses could result in serious consequences to bears. Mace and Waller (1997) believed the greatest potential for disturbance from snowmobile activity occurs when females with cubs are still confined to the den vicinity during spring and when bears descend to lower elevations and more gentle terrain, which is more suitable for snowmobiling.

Non-motorized recreation - McLellan and Shackleton (1989), indicated that grizzly bears reacted more strongly to people on foot in remote areas than to motorized equipment in more developed areas. Grizzly bears that encountered people on foot in remote areas left the creek drainage, while those grizzly bears that encountered logging equipment and motor vehicles in roaded areas moved to cover but remained in the area. Mace and Waller (1996) reported that in the Jewel Basin hiking area, a popular high-elevation hiking area east of Kalispell, Montana, bear use increased as distance from trails and lakes with campsites increased.

Encounters between grizzly bears and people often occur in national parks and wilderness areas (Martinka 1971, Craighead 1980, Klaver et al. 1985, Albert and Bowyer 1991, Jacobs and Schloeder 1992). McCullough (1982) suggested that bears be aversively conditioned to maintain their fear of humans in areas having high encounter rates. Jope (1985) reported that although bears were seen as often on heavily used trails as on trails with little human use, full-charges by bears occurred primarily on trails with little human use. Jope (1985) suggested that habituation of grizzly bears to hikers reduces the rate of fear-induced charges and consequent injuries. Albert and Bowyer (1991) reported that front-country grizzly bears in Denali National Park, Alaska, were more likely to approach hikers and campers than backcountry bears. Chester (1980) reported that, in Yellowstone National Park, hikers were more likely to encounter grizzly bears when travelling off-trail, and encounters were more likely when grizzly bears were using habitats at the same elevations as hiking trails. Mace and Waller (1996) suggested several reasons for the lack of encounters between humans and grizzly bears in the Jewel Basin hiking area including the location of trails away from preferred foraging areas.

Aversive conditioning treatments have been used to change the behavior of bears that remain at high human-use sites and along primary roads in Glacier National Park and at some private sites outside of the park (Manley 1997, Hunt undated report). Aversive conditioning treatments included use of cracker shells, rubber bullets, bean bag rounds, and hazing bears with specially trained Karelian bear dogs. Direct bear mortality from contact with humans is more common in areas outside of national parks, where people may legally carry firearms (YGBES and NCDGBES 1980s and 1990s).

Hunting - Hunting of grizzly bears has not been legal in the lower 48 states since 1991. However, black bear hunting is legal and occurs within all 6 grizzly bear recovery areas. Mistaken identification of grizzly bears by black bear hunters is a continuing problem and resulted in 6 of 19 known human-caused grizzly bear mortalities in the northern Swan Range, Montana (Mace and Waller 1997) and 6 of 113 mortalities for the NCDE as a whole during the period 1984-93. During this period, 32 grizzly bears were legally harvested, which may mask an unknown amount of mistaken identity mortality (NCDGBES 1995). Another mortality category often associated with recreation is bears killed when people felt threatened (i.e., they were in a "self-defense situation"). This category accounted for 3 of 19 mortalities in the northern Swan Range and 14 of 113 mortalities in the NCDE as a whole. Self-defense mortalities can occur when grizzly bears attempt to appropriate hunter-killed carcasses for themselves or when hunters react to surprise encounters. On Kodiak Island in Alaska, deer hunters frequently shot brown bears in conflict situations (Barnes 1994).

Structural developments - All grizzly bear recovery areas include human structural developments with concentrated human use. Often, these sites contain bear attractants including livestock and livestock feed, garbage, fruit trees, gardens and bird feeders. These sites offer potential food rewards and present high mortality risks to grizzly bears. Elgmork (1978) found that grizzly bears avoided developed cabin sites in Norway and that continued development of holiday cabins presented a threat to grizzly bear survival. Mattson et al. (1987) indicated that females and subadults in Yellowstone National Park were displaced into habitats nearer developments, where they were management-trapped at a higher rate than the same classes of bears using habitats farther away from developments. Mattson et al. (1992) found a positive correlation between the size of the whitebark pine seed crop and the frequency of human habituation among grizzly bears. Habituated and food-conditioned grizzly bears were more likely to range close to developments and more likely to be killed by humans than non-habituated bears. They further argue that destruction of habituated bears decreases the grizzly bears' ability to use available habitat and that, unless habituated bears are preserved, human facilities in grizzly bear habitat will need to be minimized.

Mace and Waller (1997) identified a higher mortality rate for grizzly bears in "rural," structurally developed areas compared to structurally undeveloped areas, with many losses in rural areas due to management removals of food-conditioned bears. The NCDE draft Grizzly Bear Incident Report for 1998 (Madel et al. 1998) reported that 82% of 263 incidents occurred on private land and that 52% were of bears near residences. Increased human population in grizzly bear habitat in the NCDE (Dood et al. 1986) was accompanied by increased mortality of grizzly bears due to management removals during 1984-93 (NCDGBES 1995).

Conclusions

Grizzly bears are sensitive to human disturbance. However, they will readily habituate to ongoing and predictable human activity. Habituation can be both negative and positive. Habituation can be positive in that human activity will not displace bears from preferred foraging areas or disrupt crucial life processes. At McNeil River Falls, Alaska, visitors view habituated brown bears at close range. Here, both bears and humans behave predictably. Visitors are restricted to tightly controlled and repeatedly used viewing areas. Transgressions by bears or people are not tolerated. Further, great care is taken to avoid any food-conditioning of bears (Aumiller and Matt 1994).

Habituation can be negative in areas where human activity is not closely regulated because habituation is usually accompanied by food-conditioning. Habituated and food-conditioned bears are dangerous because they have come to associate humans with food. The majority of human fatalities caused by grizzly bears have involved habituated and food-conditioned bears (Herrero 1989). Habituated but not food-conditioned bears can be undesirable where human behavior is unpredictable. People may act inappropriately in close proximity to a habituated bear, and thus precipitate an aggressive response by the bear (Gilbert 1989). Further, habituated bears are more vulnerable to mortality through conflict with humans, vulnerability to hunters and poachers, or through collisions with motor vehicles. In general, habituation usually leads to mortality.

Grizzly bears in multiple-use forest and wilderness environments are generally not subjected to ongoing and predictable patterns of human activity, thus they will avoid areas with heavy motorized or foot traffic and high road or trail densities. These areas simply do not offer necessary security. Those bears that do habituate to this inherently unpredictable human activity or allow the presence of attractive food resources to overwhelm their desire to avoid areas of high human use, usually end up dead. Indeed, the removal of habituated and/or food-conditioned bears is the leading cause of death for grizzly bears in the NCDE.

In multiple-use forest environments, motorized-use is primarily recreational, although administrative use also occurs. The effects of motorized recreation on grizzly bears are negative. The negative effect increases as the level of use increases. The effects of foot traffic are also negative, although fewer studies quantify the negative effects. Snowmobiling has not been demonstrated to be a problem for grizzly bears, however, as the off-trail capabilities of snowmobiles increase, the potential for conflict may also increase.

Hunters pursuing big game account for a large portion of grizzly bear mortalities. Black bear hunters mistake grizzly bears for black bears, and big game hunters shoot grizzly bears in self-defense situations. Hunters can also account for a large portion of the motorized and non-motorized use occurring on roads and trails during the fall and spring hunting seasons. This results in additive problems for bears: displacement due to increased road and trail traffic and increased risk of mortality.

Management Recommendations

As local human populations within grizzly bear recovery areas continue to increase, so will the demand for outdoor recreational opportunity. Meeting this demand while safeguarding grizzly bears will be a continuing challenge to land managers. Safeguarding grizzly bears will entail addressing 2 factors: maintaining the availability of high quality habitats for bears and reducing mortality risk.

Maintaining habitat availability

- Managers need to know the distribution of grizzly bear foraging areas within their jurisdictions. Of particular importance are low-elevation spring habitats, but traditional yearlong foraging areas and concentrated sources of vegetal and animal foods must be noted as well.
- Once the foraging habits of resident grizzly bears are known, recreational activities can be placed away from important habitats or scheduled so that human use does not coincide with grizzly bear use. Secure “core" areas need to be maintained for grizzly bears.
- Consider high elevation feeding sites
- Important seasonal habitats having limited availability and/or distribution, such as denning areas, early spring ranges, and alpine feeding areas, need a high level of protection from human disturbance. Bears may be exceptionally vulnerable in these areas or during these periods due to lethargic behavior or the inability to locate other suitable habitats.

- High quality habitats deserve special management protection, as identified above. Seasonally important habitat (such as berry-producing shrub fields) and areas of lower to moderate habitat quality, provide "space" for bears. Access should be managed to accommodate bear use, and provide a relatively low mortality risk for bears.
- Educational efforts should be directed toward areas where human use does occur within important foraging areas, such as on private lands. Sellers and real estate agents should be required to disclose to potential buyers the presence of grizzly bears and their additional stewardship responsibilities.

Reducing mortality

- Spring black bear hunters should be required to know the difference between black and grizzly bears.
- Big game hunters should be educated on the proper techniques to minimize their chances of encountering a grizzly bear such as approaching carcasses with care and removing kills during the same day or hanging them up in trees.
- The use of pepper sprays should be encouraged rather than the use of firearms to repel aggressive bears.
- Aversive conditioning techniques should be used rather than removal in order to educate habituated bears to avoid human residences.
- Rural landowners and recreational users of public lands should be educated about how to minimize attractants, prevent food-conditioning and habituation, and the use of appropriate behavior near bears.

Information Needs

There are very few studies available that describe grizzly bear responses to motorized and non-motorized trails with varying levels of human use.

PROCYONIDAE
RACCOON

Distribution , Life History and Habitat Requirements

Raccoons (*Procyon lotor*) are common and widely distributed throughout the United States, Central America, and into the southern portions of Canada. They prefer habitats in riparian areas, mesic hardwood stands, cultivated and abandoned farmlands, and suburban residential environments (Sanderson 1987). Large expanses of open prairie and dry environments are avoided. Densities vary from 0.5-5 raccoons per km^2 in highly preferred riparian areas, although a density as high as 400 per km^2 has been documented. Raccoons are most active from sunset to sunrise. In winter, raccoons go into a dormancy period, although this is not true hibernation. Their home range usually varies between 1 and 3 km^2, with males having larger home ranges. They are opportunistic omnivores. The highest causes of mortality are related to human activities: hunting, trapping, and cars. Canine distemper and rabies can be a significant problem in raccoon populations. Economically, raccoons are valued by hunters and trappers for their fur and by some for their meat.

Recreational Impacts

Recreational activities that can affect raccoons include hunting, trapping, and harassment by dogs. Habitat depletion is an impact to raccoons, and some recreational activities may lead to this situation. Raccoons are highly adaptable and can thrive in human environments when they are tolerated. Raccoons can cause agricultural damage. Raccoons also become a nuisance and are undesirable when they prey upon on eggs and young of waterfowl and upland game birds, although this is usually localized. It is illegal to keep wild raccoons as pets, and they are potential vectors for disease in domestic animals and humans.

MUSTELIDAE

Mustelids are a diverse family with 13 members found in Montana habitats ranging from semi-aquatic to grassland to forest (Appendix B). Because of this diversity, the family is handled in 3 sections of this report. The black-footed ferret, marten, fisher, and wolverine are addressed here in the Carnivore Chapter (chapter 7). Sensitive habitats that may be used by the three weasels (short-tailed, long-tailed, and least weasel), badgers, and the striped and spotted skunk are discussed in the Small Mammal Chapter (chapter 4). River otter and mink are discussed in the Semi-aquatic Mammal Chapter (chapter 5).

BLACK-FOOTED FERRET

Description

The black-footed ferret (*Mustela nigripes)* has a long, slender body that is mink-like in shape. Dorsally, it is yellowish-brown or buff; and slightly more pale ventrally. The tip of the tail and feet are dark or black. The most obvious and universally recognizable trait is the dark or black mask around the eyes, with white above and below the mask (Whitaker 1995).

Distribution

The black-footed ferret has never been considered a common species. Its secretive nature and nocturnal habits have also contributed to the lack of knowledge regarding its distribution and habits (Henderson et. al. 1974). Historically, black-footed ferrets had an extensive range extending from southern Alberta and Saskatchewan through the Intermountain West to the southwestern United States and possibly into a small part of Mexico (Richardson 1992). Their range extended eastward from the foothills of the Rocky Mountains through the grasslands of western Oklahoma, Kansas, Nebraska, and the Dakotas (BFRIT 1998).

Management Status

John James Audubon and John Bachman first described the black-footed ferret in 1851, however, little was known about ferrets until research began in the 1970s. Black-footed ferrets have a global ranking of G1 (Appendix B). It is listed as an endangered species under the ESA of 1973, and the species is administered by the USFWS. The USFWS has cooperatively developed and implemented a management recovery plan for the species.

Habitat

Black-footed ferrets are found on arid prairies and are primarily associated with prairie dog towns. They live and breed in prairie dog burrows. Ferrets may be found in other areas during dispersal, but this is an infrequent and temporary situation. Studies indicate that ferrets cannot live indefinitely on food sources other than prairie dogs (Snow 1972). Prairie dog habitat is ferret habitat.

Food Habits

The black-footed ferret is a predator that primarily hunts and eats prairie dogs (BFRIT 1998). Analysis of ferret scat indicate that when prairie dogs are scarce, ferrets will eat other rodents, including mice, gophers, and ground squirrels (Snow 1972). Additionally, they may eat birds, bird eggs and small reptiles (Whitaker 1995).

Reproduction

Little is known about the breeding habits of ferrets, but mating is believed to occur in April or May and probably occurs underground. Gestation is 41 days, and, although poorly documented, the black-footed ferret does not seem to have delayed implantation as do other closely related mustelids (Svendsen 1990). Females nest in prairie dog burrows and have been observed with 3-5 young born in late spring or early summer (Whitaker 1995).

Home Range and Movements

Black-footed ferrets are active throughout the year and do not hibernate. Ferrets are primarily nocturnal and may appear above ground for only a few minutes every few days (Hilman 1968b). Ferrets feed and dig tunnels mostly at night. In the winter, they emerge daily to feed (Progulske 1969). Movements are primarily related to hunting and seeking mates. Home range size is probably determined by the density and extent of the prairie dog colony inhabited.

Mortality

Black-footed ferrets have many potential predators including badgers, coyotes, bobcats, rattlesnakes, eagles, hawks, and owls (Svendsen 1990). Svendsen (1990) states, “Probably the most dramatic source of mortality results from the large-scale eradication of prairie dogs from the range of the black-footed ferret, thus greatly reducing their food supply.” Sport shooting of prairie dogs also has the potential for shooters to mistakenly hit ferrets emerging from prairie dog burrows, however, ferrets are primarily nocturnal, so this threat is minimal. Recreational shooting of prairie dogs does eliminate individual prairie dogs as a ferret food source. Canine distemper is 100% lethal to ferrets (Richardson 1992) and is believed to be spread by domestic dogs. Consequently, free-roaming dogs or recreationists traveling with dogs through ferret territory may spread distemper. Another introduced disease, sylvatic plague, will decimate prairie dog colonies, which leads to the loss of food and, ultimately, burrow habitat for ferrets.

Conclusions

Black-footed ferret management and their successful recovery is linked to prairie dog distribution and health. Conscientious management of prairie dog colonies will determine the future of ferret recovery.

Guidelines

- Planning for recreational facilities or activities near prairie dog colonies must carefully consider the potential spread of disease to both prairie dogs and black-footed ferrets.
- Avoid development of trails, roads and other ground disturbing activities directly on or across prairie dog colonies. Consider whether or not activities would eliminate or significantly reduce prairie dog colony size.
- Control recreational shooting of prairie dogs to preserve those wildlife species that rely upon the unique structural habitat that prairie dogs create and sustain.

Information Needs

Serious consequences could result from recreational pursuits in or near occupied prairie dog habitats. Research into how close is too close for human recreational pursuits on public lands near prairie dog habitat is needed.

MARTEN

Description

The marten *(Martes americana)* has been described as a carnivorous mammal about the size of a small house cat but longer and more slender with a bushy tail and sharp, pointed face (Strickland et al. 1982). Its total length is between 500 and 680 mm, and it weighs 500-1400 grams as an adult, depending on the individual’s sex, age, and geographic location (Buskirk and McDonald 1989, Strickland et al. 1982).

Distribution

The marten is broadly distributed ranging from spruce-fir forests of northern New Mexico to the northern limits of trees in Alaska and Canada and from the southern Sierra Nevadas of California to Newfoundland Island (Hall 1981). In Canada and Alaska, its distribution is vast and continuous, but in the western contiguous United States, its distribution is limited to mountain ranges that provide preferred habitat. Throughout the original southern limits, there has been considerable range loss due to anthropogenic factors (Strickland et al. 1982).

Management Status

In most jurisdictions in western North America where it occurs (including Montana), the marten is managed as a furbearer with regulated harvest. In 5 western states (California, Nevada, New Mexico, South Dakota, and Utah), martens may not be taken in any area at any time.

Several federal land-management agencies assign special management status to the marten. Pursuant to the National Forest Management Act (NFMA) of 1976 and its implementing regulations (36 CFR Ch. II, part 219.19 a.1.), many forest plans in Regions 1, 2, 4, 5, and 6 of the national forest system have designated the marten as an ecological indicator species or a "high interest species." Regions 2 and 5 have placed the marten on their regional forester’s sensitive species lists.

Habitat

Martens occupy a narrow range of habitat types, living in or near coniferous forests (Allen 1987). Specifically, they associate closely with late-successional stands of mesic conifers, especially those with complex physical structure near the ground (Buskirk and Powell 1994). Such structure provides denning, resting and foraging habitat, thermal and escape cover, and access to subnivian (below snow) sites. Subnivian habitat is important for resting and thermoregulation during winter (Buskirk 1989, Buskirk and Ruggiero 1994). Suitable resting sites during winter are more critical for marten than for fisher because marten are not as efficient as fisher at retaining body heat (Banci 1989). Energy conservation strategies employed by marten during winter include selection of den sites that offer optimal thermoregulatory characteristics and the ability to enter a shallow torpor (Buskirk 1989).

Forested riparian habitats along streams and meadow edges are important foraging habitats (Koehler and Hornocker 1977, Spencer et al. 1983, Jones and Raphael 1991). Marten forage at the edge of openings, especially natural meadows, but avoid traveling across large openings.

Food Habits

The diet of marten varies by season, year, and geographic area. In summer, the diet includes bird eggs and nestlings, insects, fish, and young mammals. In fall, berries and other fruits become more important foods. In winter, voles, mice, hares, and squirrels dominate the diet. In some geographic areas, single prey species are especially important because of their high availability.

In winter, marten prey on pine squirrels in the trees and on voles beneath the snow. Marten are smaller, more arboreal, and better able to hunt under snow than fishers (Banci 1989) and thus can exploit snow depths and conditions that exclude fisher.

Reproduction

Strickland, et al. (1982) summarized the reproductive characteristics of marten. Marten mate in midsummer, usually July or August. The gestation period is 220 to 276 days. Marten exhibit delayed implantation. The fertilized egg develops to the blastocyst stage in the uterus, then becomes inactive for about 190 to 250 days until implantation occurs and normal development resumes (Hamilton 1943). Jonkel and Weckwerth (1963) determined the time from implantation to parturition was approximately 27 days. Parturition is most common in April but varies from mid-March to late April. Marten produce an average of slightly less than 3 young per female. Adult females produce 1 litter per year. Adult size is attained in about 3 months. Sexual maturity in both male and females in not achieved until at least 15 months of age.

Home Range and Movements

Minimum home range size is about 2-3 km^2 for males and about 1 km^2 for females. Reported home range sizes vary widely partly due to the methods used to calculate home range. In Montana, Hawley and Newby (1957) reported 2.4 km^2 for males and 0.7 km^2 for females; Fager (1991) reported 3.8 to 18.3 km^2 for males and 1.8 km^2 for a female; Coffin (1994) later reported 2.0-17.1 km^2 for males and 2.8-9.1 km^2 for females in the same southwestern Montana study areas.

Home range size may be affected by habitat quality and food supply. Thompson and Colgan (1987) found that marten home range sizes were inversely related to food supply. Soutiere (1979) attributed larger home ranges to high levels of clear-cutting. Fager (1991) believed that the forest-grassland mosaic of one of his study areas resulted in larger home ranges than in his second, more forested study area.

Mortality

Trapping is the most direct avenue by which humans affect marten populations (Buskirk and Ruggiero 1994). The same authors report, “The effects of trapping on marten populations over most of the western conterminous United States likely are local and transient. However, trapping may adversely affect some marten populations and may have contributed to or hastened local extinctions, especially where habitat quality was poor…. The effects of trapping on demography are strongly influenced by the timing of harvest. Early season trapping tends to selectively remove juveniles, but seasons that extend into late winter or spring begin to remove more adults. Likewise, early trapping tends to selectively remove males, but trapping after the onset of active gestation shifts toward selective removal of females."

Marten are easily baited and trapped and can be overharvested where trapping pressure is heavy. In travel planning, managers should consider trapper access and distribution.

Strickland et al. (1982) document reports of marten being preyed upon by coyote, fisher, red fox, lynx, cougar, eagles, and great horned owls. Intraspecific and interspecific competition for food are likely mortality factors.

Recreational impacts, conclusions and guidelines/recommendations for marten are summarized with fisher and wolverine and follow the section on wolverine.

FISHER

Description

The fisher (*Martes pennanti*) is similar in body form to weasels and is the largest elongated terrestrial mustelid as well as the most sexually dimorphic. Adult males generally weigh between 3-6 kg and are between 90 and 120 cm long, while females weigh about 1.5-2.5 kg and are between 75 and 95 cm long (Heinemeyer and Jones 1994, Powell and Zielinski 1994).

Distribution

Fishers historically occupied much of the forested habitats of Canada and the northern United States. Populations declined in the early twentieth century, probably due to habitat loss from settlement and logging, over-trapping, and predator poisoning. Although many eastern populations have recovered, western populations have remained at low numbers or are absent throughout most of their historic range in California, Oregon, Washington, Idaho, Montana, and British Columbia (Douglas and Strickland 1987, Heinemeyer and Jones 1994).

Western Management Status

Fisher populations are formally protected in 4 western and northwestern states: Oregon, Utah, Washington, and Wyoming (Powell and Zielinski 1994). California and Idaho have closed their trapping seasons. Montana has a regulated trapping season with a quota. The U.S. Forest Service considers the fisher sensitive in all regions where it occurs, with the exception of Region 6 (Oregon and Washington). All of the western provinces and territories of Canada have open fisher trapping seasons.

Habitat

Descriptions and studies of fisher habitat are biased to habitats in eastern North America (Heinemeyer and Jones 1994). There are relatively few studies of fisher habitat in the western United States. Managers should be cautious about deciding what "is" or "is not" fisher habitat and should take a broad view of potential habitat found in their area of responsibility.

Banci (1989) concluded that, generally, habitats used by fisher have a high degree of diversity and interspersion. One of the features of having relatively large home ranges is the availability of diverse habitats. Because of the diversity of the fisher's diet, optimal habitat most likely includes a mixture of forest habitats (Arthur et al. 1989).

Heinemyer and Jones (1994) have summarized the literature relative to fisher and indicate that in the West, fishers are generally found in conifer-dominated forests containing a diversity of habitat types and successional stages. Fishers are closely associated with forested riparian areas that are used extensively for foraging, resting, and as travel corridors. Although fishers have been found to prefer mature and old-growth coniferous forest stands in most western studies, they also utilize a variety of earlier successional stages. Most studies have reported that fishers prefer forests with continuous cover, though some use of shrubby clearings can occur during certain seasons. A broader range of habitats may be used for hunting than for resting. Potential barriers to dispersal include large rivers, mountain divides above timberline, and open-canopied habitats.

Fishers appear opportunistic in their use of resting sites, with hollow logs, tree cavities and canopies, snags, rocks, ground burrows, and brush piles frequently used (Heinemeyer and Jones 1994). Mistletoe growths, often termed witches' brooms, in the canopy of large diameter trees are commonly used by fishers (Jones 1991).

Natal dens are most often in cavities of live or dead trees (Heinemeyer and Jones 1994). The absence of hardwoods in western habitats may limit the availability of suitable tree cavities for natal dens (suitable cavities being more prevalent in hardwoods). Consequently, in the absence of hardwoods, hollow logs may be more important as natal den sites in western North America than in central or eastern North America where hardwood species are more common.

Fishers are more habitat selective for resting than for foraging (Buskirk 1991). Fishers use lower elevations than marten (and are restricted to areas of lower snow accumulation than are marten) and are better adapted to earlier successional stages of forests than marten (Banci 1989).
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Food Habits

Fishers have diverse diets and probably select prey on the basis of availability. Staples in western fisher diets have been reported as snowshoe hare, ungulate carrion, sciurids, voles, and birds (Banci 1989, Jones 1991, Roy 1991, Aune and Schladweiler 1993). Prey presence and abundance may partially explain habitat use by fishers, as they may switch to more available prey species in the winter. They may compete with coyotes, fox, bobcats, lynx, marten, wolverines, and raptors for snowshoe hare.

Reproduction

Female fishers have 1 litter per year. The fisher exhibits long-term (327-358 days) delayed implantation with an active gestation of 30 to 35 days. Females may breed at 1 year of age and have their first litter at 2 years of age (Heinemeyer and Jones 1994). In a Montana study, females did not produce litters until the age of 3 (Aune and Schladweiler 1993). Based upon an average corpora lutea count of 2.2 for Montana fisher (Aune and Schladweiler 1993), reproductive potential is very low. Reported litter sizes are small, usually ranging from 1-4, with 2-3 being the norm (Heinemeyer and Jones 1994).

Most documented parturition dates in wild fishers are from mid-March into early April (Heinemeyer and Jones 1994). Parturition occurs February through May, and breeding occurs late in February to late April. The denning period lasts 8-12 weeks. Female fisher may use multiple den sites while raising kits. Kits achieve independence at 16-20 weeks of age and disperse in the late summer and early winter.

As reported in Heinemeyer and Jones (1994), breeding occurs from 2-3 days (Laberee 1941) to 3-9 days (Hodgson 1937) after parturition. Dates on fur farms were 26 March - 23 April in Ontario and 5 April - 27 April in British Columbia (Hall 1942).

Ovulation rates, frequently reported as 73-100%, may overestimate actual fecundity, as recent studies have shown denning rates to be between 34% (Arthur and Krohn 1991) and 54% (Paragi 1990). Reproductive success may be dependent on the physical condition of the females during the winter. There is evidence suggesting that reproductive potential of fishers in western habitats may be lower than that in eastern populations.

Home Range and Movements

Heinemeyer and Jones (1994) reported that males typically maintain larger home ranges, which usually encompass 1 or more smaller female home ranges. Home range estimates have ranged from averages of 2.7 to 40.8 km^2 for females and averages of 15.0 to 85.2 km^2 for males. Fishers in the northern Rocky Mountains appear to maintain larger home ranges than fishers in eastern habitats, possibly due to a lower productivity of western habitats. Generally, females have shown stability in home-range size, whereas males temporarily abandon their home ranges during breeding season in search of females.

Fishers are active both day and night, with some tendency for increased activity during crepuscular hours. A shifting of activity in response to environmental conditions, such as snow conditions or prey availability, may occur. Inactivity after large meals or during extreme weather has been noted. Fishers are capable of travelling relatively long distances in short periods (64 km in 3 days, deVos 1951). Males in particular make long distance movements during the breeding season. Some of the longest reported distances moved by fishers have been from translocated individuals: more than 100 km for males (Roy 1991, Weckwerth and Wright 1966).

Human Disturbance

Heinemeyer and Jones (1994) reported, "In New Hampshire, the presence of human activity and domestic animals appeared to have little effect on fisher movements (Kelly 1977). Arthur et al. (1989) reported that fishers in Maine tolerated a marked degree of human activity, including low density housing, farms, roads, gravel pits, and small-scale logging operations. Similarly, Kelly (1977), Jones (1991) and Heinemeyer (1993) commonly observed animals in close proximity (70-460 m) to occupied residences. Fishers in Idaho were frequently observed feeding on foods placed on window ledges of occupied dwellings for birds and squirrels (Jones 1991). Additionally, Idaho fishers were rarely flushed from their rest sites even though field researchers commonly spent as much as 1 hour within a few meters of the animal (Jones, unpubl. data)."

Females with kits may be more sensitive to human disturbance. In Maine, monitoring activity may have resulted in increased number of dens (4-5 dens per female) used by 5 females (Paragi 1990). Lactating females live-trapped in Maine did not return to a natal den and possibly abandoned the kits after the trapping incident (Arthur and Krohn 1991).

Indirectly, human activities may lead to negative impacts on fishers through the removal or development of high quality habitat, fragmentation and isolation of habitats, and increased human access to fisher populations. Although most roads may not impede fisher movements, increased trapper access may result in increased fisher mortality through direct or incidental trapping (Heinemeyer and Jones 1994). The possibility of interspecific competition with other predators that opportunistically utilize packed routes during winter should be investigated.

Mortality

Few natural causes of fisher mortality are known, and there is no evidence that other animals (except humans) prey extensively on fisher. There are documented cases of fisher choking on food, being debilitated by porcupine quills, and suffering from mange and distemper (Strickland et al. 1982, Powell and Zielinski 1994). Translocated fisher appear to experience higher rates of predation by coyotes, domestic dogs, large raptors (i.e., a golden eagle or great horned owl), and mountain lions (Heinemeyer and Jones 1994, Powell and Zielinski 1994).

Trapping has been one of the two most important factors influencing fisher populations (Powell and Zielinski 1994). They are easily trapped and are frequently caught in sets for other furbearers. Trapping may affect local populations, as even light pressure may cause local extinction. There is evidence that western fisher populations have lower natality and higher natural mortality rates as compared to eastern populations. Consequently, western populations may be more susceptible to overtrapping. Incidental captures may limit population growth in some areas (Powell and Zielinski 1994). In travel planning, managers should consider ramifications of increased trapper access and distribution.

Recreational impacts, conclusions and guidelines/recommendations for fisher are summarized with marten and wolverine and follow the section on wolverine.

WOLVERINE

Description

Banci (1994:99) describes the wolverine (*Gulo gulo*) as the largest-bodied terrestrial mustelid. Relative to smaller mustelids, the wolverine has a robust appearance, rather like a small bear. Its head is broad and rounded, with small eyes and short, rounded ears. The legs a short, with five toes on each foot. The claws are curved and semi-retractile and are used for digging and climbing. Typical weights for adult males are 12-18 kg and for adult females 8-12 kg. The coat is typically a rich, glossy, dark brown. Two pale buff stripes sweep from the nape of the neck along the flanks to the base of the long, bushy tail. White or orange patches are common on the chest.

Distribution

The historical North American distribution of the wolverine included the northern part of the continent southward to the northernmost tier of the United States from Maine to Washington and extending south into Arizona and New Mexico (Hash 1987). In the western U.S., wolverine distribution is a peninsular extension of Canadian populations within a continuous breeding group from the 38th parallel northward (Hash 1987, Banci 1994). Wolverine populations in Montana were near extinction by 1920 (Newby and Wright 1955), but numbers increased in the western part of the state from 1950 to 1980 (Newby and McDougal 1964, Hornocker and Hash 1981).

Management Status

The United States, wolverine may be trapped for fur only in Alaska and Montana. In Montana, trapping has been limited by seasons, licensing, and seasonal limit of 1 wolverine per trapper (Hornocker and Hash 1981, Banci 1994). Petitions have been filed for listing the wolverine under the ESA for California and Idaho (Banci 1994). Regions 1, 2, 4, and 6 of the U. S. Forest Service and the BLM categorize the wolverine as a sensitive species.

Habitat

Broadly speaking, the wolverine is restricted to boreal forests, tundra, and western mountains, but they have not been found associated with any particular vegetative community. Habitats used by wolverines appear to vary geographically and seasonally. Preferences for some forest cover types, aspects, slopes, or elevations have been primarily attributed to a greater abundance of food (Gardner 1985, Banci 1987) or the avoidance of high temperatures or humans (Hornocker and Hash 1981). The current distribution of wolverine coincides with areas of low human occurrence; this represents a substantial reduction from its historic range.

The most specific habitat need of wolverine may be for denning. All authors agree that the use of reproductive dens begins in early February to late March (Copeland 1996). Female wolverines in central Idaho preferred secluded subalpine talus sites in cirque basins for natal and kit rearing dens (Copeland and Harris 1994, Copeland 1996) from which they made foraging trips as far away as 15 km. The concave nature of a cirque may enhance longevity of snow depth, thereby ensuring the integrity of den structure into late winter. Large boulder talus provides cavities used as natal and nursery dens. Post-weaning rendezvous sites for kits and adult females included large boulder talus and structurally mature spruce/fir riparian sites with dense understory and forest floor debris for security and hiding cover. Such sites were often associated with subalpine rock/scree. Boulder talus was also associated with foraging during winter and summer months and may be important as thermal cover.

In the spatial and temporal planning of human activities, it is advisable to consider the apparent specific denning needs of wolverine.

Food Habits

Wolverine are generally described as opportunistic omnivores in summer and primarily scavengers in winter. All studies have demonstrated the importance of large mammal carrion. Wolverine appear to rely on carrion (ungulate and/or livestock) during winter when other foods are less available.

Reproduction

Wolverines exhibit delayed implantation, where development of the embryo is arrested at the blastocyst stage. Implantation in the uterine wall can occur as early as November (Banci and Harestad 1988) or as late as March (Rausch and Pearson 1972), birth can, therefore, occur as early as January or as late as April (Banci and Harestad 1988). Parturition rates in wolverine may correspond to increased amounts of ungulate carrion in late winter.

Wolverine have low reproductive potential. Females do not breed their first summer (Banci 1994). Most males are sexually immature until 2+ years of age (Rausch and Pearson 1972, Banci and Harestad 1988). In Montana, only 50% of adult females were thought to be pregnant in any year of a 5-year study (Hornocker and Hash 1981). Litter sizes as large as 6 in captive animals (Rausch and Pearson 1972) and 4 in wild ones have been reported, but litter size after den abandonment is typically fewer than 3 (Pulliainen 1968, Magoun 1985). Older females seem capable of producing larger litters, but fewer females in these older age classes may produce litters (Banci 1994).

Home Range and Movements

The spatial requirements of wolverine may be as large as for any mammal in North America. Home ranges of wolverine in Idaho ranged from 80 to 700 km^2 for females and more than 2,000 km^2 for males (Copeland and Harris 1994). Wolverine occurrence is most likely keyed to food availability (Garner 1985, Whitman et al. 1986, Banci 1987) and selection of den sites.

Mortality

Banci (1994) summarized that wolverines have few natural predators and while they are occasionally attacked and killed by wolves and other large carnivores, they are seldom eaten. Starvation likely is an important mortality factor for young and very old wolverines. Throughout most of its distribution, the primary mortality factors are trapping and hunting. Banci (1994) reported that in several telemetry studies, trapping accounted for more than half of all mortalities. Lacking more information, little can be said of the additive or compensatory nature of trapping mortality. But Banci (1994) stated that harvest of juvenile wolverine, especially early in the season, may be compensatory because of their suspected high natural mortality. Some harvest of adults, specifically those which are nutritionally stressed, also will be compensatory. But, in general, Banci believed that the harvest of most adults is additive to natural mortality.

Recreational Impacts upon Marten, Fisher, and Wolverine

Literature that focused on human effects resulting from recreation was not located for the mustelids. Rather, in terms of human effects, the literature focused on direct mortality from trapping and on the effects of habitat alteration. Some papers reported anecdotal observations of disturbance. For example, Heinemeyer and Jones (1994) summarized potential human disturbance effects on fisher as reported in the literature. Hornocker and Hash (1981) suggested that human access via snowmobile or all-terrain vehicles in winter or early spring could disturb wolverines. Copeland (1996) suggested that subalpine cirque areas, which are important for wolverine natal denning, may be rendered unavailable by winter recreational activities.

Examples of marten, fisher, and wolverine responses to humans are characteristic of the 3 learned responses described by Knight and Cole (1991): (1) habituation, (2) attraction, and (3) avoidance. Habituation is defined as "the waning of a response to a repeated stimulus that is not associated with either a positive or negative reward" (Eibl-Eibesfeldt 1970 *in* Knight and Gutzwiller 1995). Knight and Temple (1995) define attraction as the strengthening of an animal's behavior because of rewards or reinforcement (such as food). But, wildlife learn to avoid humans when these interactions are associated with pain or punishment.

Gabrielsen and Smith (*in* Knight and Gutzwiller 1995) provide abundant evidence of the physiological response of some wildlife to both natural and human-caused disturbance. These include elevated heart rate, metabolism, blood sugar, body temperature, respiration rate and depth, oxygen consumption, and brain and heart blood flow. When marten, fisher, and wolverine are disturbed by humans, similar physiological responses likely occur and have energetic costs.

Animals that learn to avoid areas of human activity do so at the cost of repeated disturbance and ultimately forego the resources available in the avoided area. Even those individuals exhibiting an attraction or habituation response may do so at a cost. For example, animals attracted to human food sources may experience poor nutrition and may be exposed to mortality risks not necessarily encountered in their "wild" environments. These include conflicts with domestic pets and exposure to their diseases, risk of incidental trapping or shooting, and being struck by vehicles. Habituated individuals develop their behavior only after the cost of repeated stimulation, and they too may expose themselves to greater risk of mortality.

Wolverine, fisher, and marten are all renowned for their vulnerability to trapping and susceptibility to overharvest (Powell 1979, 1982; Weaver 1993). Roads and trails (especially snowmobile trails) developed for recreation are also used by trappers and, therefore, increase vulnerability of these species to trapping mortality. Even where protected by law, incidental catch of these species in traps set for coyote or bobcat result in mortality (lethal traps, weather extremes while in the trap, time in trap). Even if released as an incidental catch, injuries to limbs or teeth may result in an inability to hunt, resulting in subsequent mortality. Overharvest of low-density populations may lead to reduced dispersal or local extinctions, especially in fragmented habitats.

It is generally recognized that refugia (landscapes, generally wilderness or back-country, that are not subject to trapping) are necessary for the long-term persistence of forest carnivore populations. Refugia serve as source populations to repopulate trapped landscapes via dispersal and immigration (Banci 1989, Weaver 1993). Without the insurance value of source populations in refugia, the impacts of trapping (including incidental catches) may be significant.

Introduction of dogs may result in direct or indirect mortality of dependent young, or the introduction of disease. Canine distemper has occurred in marten (Fredrickson 1990). Canine and feline distemper occasionally cause localized high mortality in fishers. Fisher are susceptible to sarcoptic mange (Banci 1989).

Conclusions for Marten, Fisher, and Wolverine

Due to their large home range requirements, specialized habitat needs, low reproductive potential, and inability to disperse across areas of unacceptable habitat, fisher and wolverine, and to a lesser extent marten, are susceptible to habitat fragmentation and population isolation. Certain recreational activities as well as poorly placed roads and recreational trails may contribute to these impacts.

Wolverine and fisher hunt patchily distributed prey and, therefore, require large home ranges disproportionate to their body size. Large home range size and low fecundity result in low densities. Low-density species are more vulnerable to local extinctions (populations with inherent low densities are generally unable to compensate for mortality).

In many landscapes, occurrence of habitats that fill the specialized habitat requirements of marten, fisher, and wolverine have been reduced as a result of logging practices (loss of old growth/structurally mature conifer stands with multiple canopies and downfall) and recreational use of subalpine cirques (ski resorts, snowmobile trails and play areas, heli-skiing, and extreme snowboarding).

In the absence of a complete knowledge of habitat requirements, consideration of recreational activities on public lands should err on the side of the requirements of the productive female segment of populations, including habitat and energy requirements associated with gestation and lactation.

Hornocker and Hash (1981) emphasized the importance of untrapped, remote wilderness areas for the viability of wolverines, and recommended curtailment of bait trapping in areas where wolverine population enhancement is desired. Weaver (1993) recommended establishment of a network of trapping refugia to provide for long-term conservation of fisher and wolverine populations.

Human activity may have the effect of altering species composition in local areas or over geographic landscapes. Snowmobile or ski trails may facilitate entry of species (on packed snow paths) that would otherwise be excluded by virtue of snow depth or conditions. Changes in species composition (range extension of coyotes, bobcats, lions, wolves) may result in competition for food (prey species or carrion) and/or predation pressures that otherwise would not occur. Carrion is an important winter food source for wolverine. Therefore, displacement of ungulates or competition for carrion as a result of changes in species composition in an area may negatively effect wolverine.

Guidelines and Recommendations for Marten, Fisher, and Wolverine

- Planning of recreational developments with consideration for these forest carnivores must, by necessity, be accomplished at the landscape scale (these species have low-density populations with large area and specialized habitat requirements and have been diminished as a result of historic land uses); incorporate the concept of refugia (integrity of landscapes that can support unexploited source populations of species characterized by low reproductive potential and low dispersal abilities); and consider cumulative effects of recreational developments and other land uses within the landscape.
- Recreation should be directed to designated travel routes.
- Locate road or trail routes or other recreational facilities in a manner that does not impact habitats important to wolverine for denning and foraging (subalpine boulder talus sites or structurally mature montane forests associated with subalpine rock/scree habitats). Natal and kit-rearing habitat for wolverine should be protected from disturbance 1 January through 30 May. Female wolverines are sensitive to disturbances in habitats selected for natal dens and kit-rearing den/rendezvous sites. Den desertion has been documented in Idaho by Copeland (1996) and in Finland by Pulliainen (1968).
- Drainage bottoms with riparian coniferous forests/mesic forest types appear to be preferred habitat for fisher and marten (Buskirk et al. 1994, Heinemeyer and Jones 1994, Powell and Zielinski 1994). Within the distribution

of fisher and marten, management strategies designed to maximize the benefits of these habitats would be desirable.

- Trapping of terrestrial furbearers should not be permitted within designated refugia in order to prevent incidental capture of fishers (Heinemeyer and Jones 1994).
- Loop trails that bisect or run parallel to preferred habitats for these medium-sized forest carnivores should be avoided because loop trails may foster: (1) an exponential increase in the volume of recreational use, (2) high trapping pressure/excessive trapping mortality, and (3) an exponential increase in the extent and duration of disturbance to wildlife in the geographic area affected.
- Roads and trails are directly correlated with trapper access to forest carnivore populations and, therefore, vulnerability of forest carnivores to trapping mortality. Impacts of increased trapping mortality of forest carnivores as a result of recreational development/use should be considered, especially if the recreational development is located in an area that currently/previously served as a refugia/source population. The following measures could be used to reduce the potential for increased trapper harvest associated with snowmobile trails:
  - Avoid establishing road or trail routes that bisect or run parallel to preferred habitats.
  - Avoid establishing road or trail routes that follow forested saddles linking major drainages (travel routes for forest carnivores).
  - Avoid establishing road or trail routes that separate mature, closed canopied forests from foraging habitats for fisher and marten (Spencer et al. 1983, Buskirk et al. 1989, Jones and Raphael 1991).

Information Needs for Marten, Fisher, and Wolverine

In the absence of more information, managers must consider the ecology, habitat associations, reproductive needs, and life-cycle necessities of marten, fisher, and wolverine in the planning and analysis of recreational activities. In addition, implementation of the following specific research needs could provide beneficial direction for the management of these species with respect to planning and implementation of recreation projects:

- An understanding of habitat relationships and population dynamics of snowshoe hare.
- Habitat requirements and selection.
- Effects of various forest management practices on distribution and population dynamics.
- Impacts of habitat fragmentation on population dynamics and population viability.
- Impacts of trapping mortality on population dynamics (including emigration).
- Determine the relative contribution to regional populations of untrapped and undisturbed refugia.
- Tolerance to disturbance by recreationists at various seasons of the year.
- Potential for introduction of diseases via anthropogenic pathways.

FELIDAE

Three species of wild cats occur in Montana: mountain lion, bobcat, and Canada lynx. Bobcats are referenced in the lynx section. A downloadable report on the relationship of recreational activities and bobcats may be available in the future at the Montana Chapter of The Wildlife Society web site (www.montanatws.org). Lynx have recently captured the scientific and social debate revolving around its possible listing as a threatened species (in early 2000) under the

ESA. The full text of the available chapters of Scientific Basis for Lynx Conservation (The Lynx Science Report) may be viewed on-line at the U.S. Forest Service Northern Region web site www.fs.fed.us/r1.

LYNX

Description

Canada lynx *(Lynx canadensis)* are medium-sized cats with a flared, facial ruff; black ear tufts; and a short, black-tipped tail (Banfield 1974). In North American populations, head and body length are approximately 800-1,000 mm, tail length 51-138 mm, and weight 5.1-17.2 kg (Banfield 1974, Burt and Grossenheider 1976). Males are generally larger than females. The legs are relatively long with large, densely furred paws that allow them to travel across deep snow typical of their higher elevation habitat in winter.

Distribution

Throughout North America, lynx distribution typically coincides with the distribution of snowshoe hares (McCord and Cordoza 1984, Bittner and Rongstad 1984) and within this range overlap, lynx usually occur in the habitats where snowshoe hares are most abundant (Koehler and Aubry 1994). The range of the lynx has included Washington, Oregon, Idaho, Wyoming, and Montana, and possibly Utah and Colorado; Minnesota, Michigan and Wisconsin; and New York, Vermont, New Hampshire and Maine. There are also records from North and South Dakota, Nebraska, Illinois and Pennsylvania (McKelvey et al. 1999). The only known remaining population strongholds in the United States are in Washington (Okanogan National Forest) and western Montana and possibly northern Idaho. There are 2 radio-collared lynx in the Wyoming Range, Wyoming (Squires and Laurion 1999) and 1 radio-collared lynx in northern Maine. Forty-one lynx were released in southern Colorado commencing on February 3, 1999 (G. Byrne, Colorado Division of Wildlife, personal communication).

Management Status

The lynx in the contiguous United States has been "proposed" for federal listing by the U.S. Fish and Wildlife Service under the ESA of 1973. Harvest is closed in all states, except Montana where there has been an annual quota of 2 since 1991. The Montana trapping regulations for season 1999-2000 closed lynx trapping and specified a quota of up to 5 that may be live-captured for relocations (B. Giddings, MFWP, personal communication).

Lynx have been categorized as “sensitive” by the Bureau of Land Management (BLM) and he U.S. Forest Service in Regions 1, 2, 4, 6, and 9.

Habitat

Lynx are typically found in mid to upper elevation coniferous forests in the cool, moist vegetation types. Mature coniferous forest stands as well as seral stages are important. In Montana west of the Continental Divide, primary lynx habitat is defined as subalpine fir, Engelmann spruce, moist Douglas-fir and moist grand fir *(Abies grandis)* habitat types usually between 4,100 and 7,000 feet elevation. Stands of mixed species composition (subalpine fir, Douglas-fir, grand fir, western larch *(Larix occidentalis)*, lodgepole pine, and hardwood) and stands dominated by seral lodgepole pine also provide lynx habitat (J. Squires, Rocky Mountain Research Station, personal communication). On the east side of the Continental Divide, elevation ranges of subalpine forests are higher, approximately between 5,500 and 8,000 feet elevation. Subalpine fir, Engelmann spruce, and moist Douglas-fir habitat types where lodgepole pine is a major seral species, provide primary habitat. Elevation zones should only be considered as a general habitat guide.

For more detailed lynx habitat descriptions see the draft Canada Lynx Conservation Assessment and Strategy (U.S.D.I. Bureau of Land Management [BLM] et al. 1999).

Denning Habitat

Limited research on lynx in the southern portions of their range (i.e., southern Canada and the contiguous U.S.) has resulted in only a few descriptions of natal and maternal den sites. In north-central Washington, Koehler (1990) located 4 maternal den sites used by 2 females during his study. These dens were located on north-facing slopes in mature (>250 years) forest stands of spruce, subalpine fir, and lodgepole pine. In Wyoming, Squires and Laurion (1999) described a den site located in mature subalpine fir forest with co-dominant lodgepole pine and relatively dense understory cover from large woody debris and saplings. In Montana, the habitat characteristics of 4 dens located in May 1999, have not yet been specifically reported, but all 4 dens were associated with coarse woody debris (Squires and Laurion 1999).

In summary, the critical habitat component(s) for maternal dens appear to be mature forest, understory structure that provides security, and thermal cover for kittens (Aubry et al. 1999). Suitable understory structures are generally found in unmanaged, mature forests where blowdown patches of coarse, woody debris occur. A minimum size of these "patches" is not reported. However, recent research in the Yukon (Mowat et al. 1999) demonstrates that lynx may den in younger, regenerating stands (30 years old) that contain blowdown or structures such as roots and dense vegetation that seem to provide similar cover characteristics as described above. Understory structure may well be the critical component rather than forest stand age.

Food Habits

In northern latitudes, lynx prey almost exclusively on snowshoe hares in winter and primarily snowshoe hares with some alternate prey such as red squirrels (Mowat et al. 1999) in summer and low hare cycles. Lynx are dependent upon snowshoe hares in the North where they reach their highest densities and populations undergo dramatic 10-year cycles in delayed synchrony with snowshoe hare populations (Keith 1963, Mowat et al. 1999). In southern boreal forests, there are few studies on lynx food habits, though limited information indicates a similar importance of snowshoe hares in the diet (Koehler and Aubry 1994).

Because snowshoe hare densities are typically low in southern boreal forests compared to northern boreal forests (northern low-cycle densities are comparable to southern boreal forest average hare densities) (Hodges 1999), it appears that alternate prey species, such as red squirrels *(Tamiasciurus hudsonicus)* (Koehler 1990), northern flying squirrels *(Glaucomys sabrinus)*, voles, grouse and deer carrion, are important as well (Apps 1999). Interestingly, there are several reported observations of lynx hunting ground squirrels. During summer in Glacier National Park, Montana, Barash (1971) observed 2 adult and 1 juvenile lynx cooperatively hunting Columbian ground squirrels *(Spermophilus columbianus)*. There have been additional observations of this circumstance in Glacier National Park and the Seeley Lake study area (J. Squires, RMRS, personal communication). In Wyoming, Squires and Laurion (1999) reported a male lynx hunting Wyoming ground squirrels *(S. elegans)* in sagebrush habitat in late April, and a female lynx hunting similarly in early July. These observations indicate ground squirrels may be an important summer food item in the intermountain west. (Squires and Laurion 1999, Lewis and Wenger 1998, McKelvey et al. 1999).

It is important to note the dependence of lynx upon snowshoe hares as a food source in their primary habitat, i.e., mid to upper elevation coniferous forests in the southern latitudes. At the same time, generalist predators such as coyotes and bobcat (and other predators such as mountain lions, fisher, northern goshawk, great horned owl) also utilize snowshoe hares whenever they can. Rolley (1987) and Quinn and Parker (1987) reviewed the diets of lynx and bobcats and found they both tend to be dominated by leporids, creating the potential for exploitative resource (hares in this case) competition (Litvaitis 1992).

Home Range

Squires and Laurion (1999) reported that annual home range sizes are large based on preliminary telemetry data. This supports the Koehler and Aubry (1994) contention that lynx home ranges in the southern part of their range are usually larger than lynx home ranges in the northern part of their range. There may be several reasons for this differential, but it may be related to prey availability and density. In Montana, Squires and Laurion (1999) found that annual 95% minimum convex polygon home ranges of males averaged 238 km^2 and annual female home ranges averaged 115 km^2. This agrees with most lynx populations (Brainerd 1985, Koehler 1990, Poole 1994, Slough and Mowat 1996), where characteristically male home ranges are much larger than female home ranges.

Reproduction

Lynx recruitment is associated with snowshoe hare abundance (Nellis et al. 1972, Brand and Keith 1979, Parker et al. 1983, Bailey et al. 1986, Slough and Mowat 1996). Recruitment is high when hares are abundant, primarily due to increased kitten survival. O'Connor (1986) determined that lynx ovulate from late March to early April and give birth in late May after a gestation period of 60-65 days based upon necropsied carcasses from Alaska. In north-central Washington, kittens observed in early July (Koehler 1990, unpubl. data) appeared to have been born in late May or early June. In Montana, kittens were born in late May or early June (J. Squires, pers. comm.).

Mortality

The most commonly reported causes of lynx mortality include starvation of kittens (Quinn and Parker 1987, Koehler 1990) and direct human-caused mortality, primarily by trapping (Ward and Krebs 1985, Bailey et al. 1986). Predation on lynx by mountain lion, coyote, wolverine, gray wolf, and other lynx has been documented (Berrie 1974, Koehler et al. 1979, Poole 1994, Slough and Mowat 1996, O'Donoghue et al. 1997, Apps 1999, Squires and Laurion 1999).

Mortality is influenced by the relative abundance of snowshoe hares (Koehler and Aubry 1994). In northern populations, starvation was found to be a significant mortality factor during the first two years of hare scarcity (Poole

1994, Slough and Mowat 1996). Females are more likely to feed themselves first, resulting in significant kitten mortality due to starvation (Brand and Keith 1979) when snowshoe hare numbers are low.

Squires and Laurion (1999) reported 6 lynx mortalities in Montana during their study. Necropsies conducted by personnel of Montana Fish, Wildlife and Parks (MFWP) documented these causes: 3 animals died of starvation, 2 were killed by mountain lions, and 1 died of unknown causes.

Interspecific Competition

Buskirk et al. (1999) described two types of competition that can impact lynx: (1) exploitation competition for resources, food in this case; and, (2) interference competition (Case and Gilpin 1974), i.e., when one species acts aggressively toward another and thereby denies access to a resource or causes an injury or mortality. Several predators compete with lynx for snowshoe hares such as northern goshawk *(Accipiter gentilis)*, great horned owl *(Bubo virginianus)*, coyote, red fox, gray wolf, mountain lion, bobcat *(Felis rufus)*, and wolverine *(Gulo gulo)*. Of these, the coyote is considered the most likely to cause exploitative competition with lynx (Buskirk et al.1999).

Deep, low-density snow allows lynx to exploit higher elevation areas during winter that typically exclude competitors such as coyotes, bobcats, and mountain lions (Parker et al. 1983, Koehler and Hornocker 1991, Brocke et al. 1992). Comparative measurements of lynx paws show their relative support capacity to be twice that for bobcat paws (Parker et al. 1983) and 4.1 - 8.8 times that of coyote paws (Murray and Boutin 1991). Buskirk et al. (1999) reported foot loadings (an estimate of pressure exerted by the animal walking on snow, therefore its sinking depth) for several species and found that snowshoe hare had the lowest value; fisher and lynx about the same values; and that bobcat, coyote, wolf, and mountain lion all had considerably higher foot loading values. In this comparison, species with the higher values would sink deeper into the snow and, therefore, have to exert more energy to traverse snow while walking. Opportunities for resource (hares) competition increase among these species when snow compaction occurs into higher elevations due to recreational (or management) activities such as snowmobiling, skiing, snowshoeing, and roads/trails that are plowed or groomed (Koehler and Aubry 1994). Buskirk et al. (1999) concluded that exploitation competition by coyotes, may reduce lynx numbers in the southern parts of lynx range where hare numbers are low. Coyotes and bobcats, and particular mountain lions appear to be effective interference competitors.

Recreation

Several authors (Bider 1962, Ozoga and Harger 1966, Murray and Boutin 1991, Koehler and Aubry 1994, Lewis and Wenger 1998 and Buskirk et al. 1999) suggested that packed trails created by snowmobiles, cross-country skiing, snowshoeing, snowshoe hares, and other predator trails may serve as travel routes for potential competitors and predators of lynx.

Mowat et al. (1999) reported that lynx seem to be able to tolerate moderate levels of snowmobile activity and human presence. There is very little information on this topic. Human presence at denning time in late May and June may be the time that human disturbance affects lynx by causing den abandonment and potentially affecting kitten survival. It has been observed that human presence at a den site with young kittens can cause the female to move her young to another site (J. Squires, Rocky Mountain Research Station, personal communication).

Developed recreation sites such as resorts, ski areas, and campgrounds cause a direct impact through habitat loss/modification and the addition of various human activities in an area. These types of developments necessitate analyses of on-site impacts as well as a landscape-level view to analyze cumulative effects and whether the development occurs in large blocks of contiguous lynx habitat versus highly fragmented areas of lynx habitat. These broader levels of analysis provide the means to address issues of connectivity, refugia, and metapopulations. For a more detailed discussion of these analyses for dispersed and developed recreation see the draft Canada Lynx Conservation Assessment and Strategy (USDI Bureau of Land Management, et al. 1999).

Conclusions

Lynx are specialized predators that are adapted to procuring their primary prey, snowshoe hares, in deep snow habitats. Management and/or activities that reduce snowshoe hare numbers or the competitive advantage of lynx, affect the ability of lynx to effectively utilize winter habitats, reproduce, and survive. Lynx seem able to tolerate moderate levels of human disturbance, except during denning and rearing of offspring. More research information is needed to quantify interspecific competition relationships and their impact on lynx.

Guidelines/Recommendations

1. Within lynx habitat, analyze potential impacts of proposed projects that would increase snow compaction, thereby facilitating travel of predators that are competitors with lynx in and adjacent to the proposed project area.
2. Minimize activities that increase current levels of human-induced snow compaction in lynx habitat until more research on this topic is completed.
3. Manage snowshoe hare habitat to maintain or increase current population levels.
4. Provide landscapes that encompass the full range of forest structure stages including mature forests for red squirrels, snowshoe hares, and denning habitat.
5. For a more complete list of management guidelines, see the draft Canada Lynx Conservation Assessment and Strategy (BLM 1999).

Information Needs

1. Determine the extent to which lynx compete with other predators for prey and under what conditions competition may adversely affect lynx populations (Koehler and Aubry 1994).
2. Determine the direct and indirect impacts of recreation including how snow compaction alters interference competition among forest carnivores.
3. Further examine lynx habitat use relative to forest structure and localized abundance of snowshoe hares in the southern portions of lynx range as it may relate to ongoing and proposed recreation developments.
4. Determine where lynx occur throughout their range, and specifically in Montana, identify mountain ranges that sustain lynx.
5. Determine patterns of snowshoe hare abundance across a gradient in Montana that extends from north to south.

MOUNTAIN LION

Life History and Habitat Needs

Mountain lions (*Puma concolor*) are highly specialized predators adapted to thrive in a broad diversity of habitats. Historically found across North America (Young 1946), their range is now reduced to portions of southern Florida and the mountainous regions of western United States and Canada. Yet, this large predator has reclaimed much of its former range in Montana since classification as a game animal in 1971 and currently is found in 46 of 56 counties (MFWP 1996).

This solitary hunter commonly kills prey as large or larger than itself, primarily deer and elk. The dispersion of prey and the necessary vertical and horizontal cover for stalking greatly determines the large areas required by lions. Territories of males in the northern greater Yellowstone ecosystem were largely exclusive of other males, overlapped 1 to 3 female ranges, and averaged 350 km^2. Female home ranges were approximately 140 km^2 (Murphy 1998). In western Montana, male territories were 290 km^2, overlapped several female home ranges that averaged 132 km^2, and were also largely exclusive of other males (Murphy 1983). Unusually small home ranges for male (96.4 km^2) and female lions (58.1 km^2) were found in the Sun River study area in Montana, and adult male lions showed considerable home range overlap with other adult males and females (Williams 1992).

Female home range size is also dependent on available den sites and security cover. Dens in Wyoming and southwest Alberta were located in dense shrub fields, rock outcrops, and beneath downed conifers (Murphy 1998). Mean litter size ranges from 2-4, but less than half of the kittens in the northern greater Yellowstone ecosystem survived to independence (11-22 months old). Approximately two-thirds of these surviving subadults dispersed to other areas. One subadult male dispersed 174 km to southern Idaho (Murphy 1998). The importance of subadults dispersing long distances and enhancing other lion populations has also been documented in Idaho, Wyoming, Utah, New Mexico, and California (Seidensticker et al. 1973, Logan et al. 1986, Beier 1993, Laing and Lindzey 1993, Logan et al. 1996).

Recreational Effects

Habitat fragmentation - Habitat fragmentation and degradation resulting from human development and disturbance are the most serious long-term threat to lion populations (Murphy 1998). The identification of travel corridors that allow exchange of dispersing subadults and an evaluation of lion tolerance to human activities within these corridors will ensure persistence of lion populations. Beier (1995) found that lions avoided corridors with excessive noise, lighting, and domestic dogs, yet readily used corridors with isolated residences without lighting, quiet motors, and trails heavily used by hikers, bicyclists, and equestrians.

Influence on home range - Jalkotzy and Ross (1995) expanded their research to focus on the effects of human activities on the Sheep River lion population in Alberta. They compared summer activities of lions in a relatively high-use recreational area with a secondary road, campgrounds, and a network of equestrian and hiking trails to winter lion movements when the area was closed to recreation. They stressed that while human activities in the study area were variable and discontinuous, the lions appeared well-adapted to human recreation. Lions did not abandon their core home ranges to avoid contact with humans, though lions appeared sensitive to human disturbance at kill sites. Lions matched ungulate movements, both shifting activities to late afternoon until early morning, the period when humans were more inactive. One female whose home range bordered a relatively busy recreational area shifted to the backcountry to give birth. Another female also shifted her home range to reduce human contact when her offspring were very young, yet the natal den was hidden in a thick understory of spruce only 125 m from a well used trail. Lions occupied areas 250 m from heavily used campgrounds and picnic sites. The researchers concluded that human activities in localized areas did not deter lions from utilizing the immediate vicinity, but that the impact of human disturbances on lion populations needs additional research .

Behavioral changes - In the Chisos Mountains of Big Bend National Park in Texas, McBride and Ruth (1988) also examined lion activities around human recreational areas such as campgrounds and trails. Significant behavioral changes did not occur between periods of heavy and light visitor use, and lion home ranges overlapped heavy visitor use areas. Trails were used by lions as travel corridors, and they also documented a shift of lion activity to late evening/early morning when human activity was minimal. No correlation existed between the number of hikers on a trail and the distance of the lion from that trail. Lions often moved through visitor use and residential areas during nightly movements. When human activities increased in the morning, lions tended to move into drainage ways, which provided more cover than trails. Daybeds were relatively close to trails without human-lion interactions. Lions would move from a bedsite when a human was within 2.1 to 137.2 m, indicating individual tolerances to close human presence. Most of these lions would then move quickly through thick brush and were not visible to the human observer.

Van Dyke et al. (1986) investigated the reactions of lions to logging and human activities in Utah and Arizona. Although logging activities are significantly different from recreational pursuits, they also documented lions modifying their behavior to avoid human disturbance. Lions shifted their activities between sunset and 3-4 hours before sunrise. In contrast to the previous studies, lions in both Utah and Arizona resided in areas relatively free of human disturbances. They concluded that continuous, concentrated human presence or residence eliminated the use of the habitat by lions, even if there was little impact on the habitat by humans.

Similarly, Maehr (1990) suggested that Florida panthers were avoiding the human disturbances caused by deer hunters in Big Cypress National Preserve, utilizing the area less than expected during the hunting season. Belden et al. (1991) also reported displacement of recently translocated lions from home ranges by disturbances associated with hunting seasons. Murphy (1998) questioned how hunting activities affects prey species and the corresponding impact of lions. When ungulates adjust their activities to avoid humans (Lyon 1979, Edge et al. 1985) and select habitats with increased cover, lions may actually benefit in acquiring prey if vegetation also increases concealment of the lion (Murphy 1998). Yet, recreational hunting of ungulates may modify the sex and age structure of ungulate prey populations and thus affect lions (Murphy 1998).

Influence of roads - As access to recreational areas increases, the avoidance of roads by mountain lions may further fragment lion habitat and decrease dispersal of subadults. Lions in Arizona and Utah established home ranges in areas where improved dirt roads were underrepresented or absent and crossed these roads less than expected. Most lions frequently crossed unimproved dirt roads (Van Dyke et al. 1986). Yet, lions in Alberta did not avoid or prefer the secondary road corridor during the high-use summer recreational season. Lions did travel across the road during daylight, though they crossed more often between late afternoon and early morning (Jalkotzy and Ross 1995). Lions in Utah and Arizona selected areas with lower road densities than average on 2 study areas, yet in another region lions tolerated higher road densities when areas with lower densities were not available (Van Dyke et al. 1986).

Only 1 lion died from an automobile collision in 115 monitored lion mortalities in 3 western states (Anderson 1983). Yet, small lion populations in southern California and southern Florida occupy habitats that are highly fragmented by roads and human disturbances, have experienced significant automobile-caused mortality. Underpass crossings, fencing, and road modifications have been built to mitigate this impact (Maehr et al. 1991, Beier and Barrett 1993).

Roads that increase access to recreational areas can dramatically impact local lion populations by increasing access to lion hunters. Most lion hunters in Montana and Utah use automobiles to locate lion tracks and transport hunting hounds. The type, density, and distribution of roads within a lion's home range; lion movements and weather patterns greatly influence hunter success (Murphy 1983, Barnhurst 1986).

Hunting - Montana Fish, Wildlife and Parks developed a conservative hunting program, because of the difficulty in obtaining accurate population survey data (Aune 1991). One lion/license holder limit and female, male, and/or total quotas exist for hunting districts statewide. Once a quota has been reached, lions can only by "chased" within that district. An additional fall hunting opportunity for lions exists, though hounds can not be used to pursue lions. Current trend indices indicate that lion populations in Montana are increasing (Aune 1991).

The recreational hunting of lions is usually the greatest source of mortality for hunted lion populations (Murphy 1983, Logan et al. 1986, Ross and Jalkotzy 1992, Murphy1998). In addition to the intended mortality of the hunted lion, additional mortality of kittens may occur when hunters do not identify the female as lactating, especially during fall hunts when hounds are not used and when kittens are accidentally mauled by hounds (Barnhurst and Lindzey 1989). Whereas pursuit-only seasons have been regarded as nonconsumptive, the physiological effects of chasing mountain lions are poorly understood (MFWP 1996). Harlow et al. (1992) found a lowered plasma cortisol profile in mountain lions put through simulated pursuits, indicating an altered physiological response of the adrenals to the stress of repeated chases. Also, the long-term consequences of hunting on the social organization of lions are unknown. Lion hunting for recreational sport does not mimic natural mortality patterns, as hunters tend to select for large, experienced males (Sweanor 1990, Logan et al. 1996, Murphy 1998). Twenty-six percent of the female lions in New Mexico produced 50% of the population's kittens, and 47% of the adult males sired these litters (Logan et al. 1996). Only nine males sired 23 litters in Wyoming (2 males sired 14 litters) (Murphy 1998). The consequences of lion hunting on the reproductive potential of a population are unknown.

The legal harvest of lions not only provides recreation but also could reduce potential conflicts between humans and lions (Aune 1991). Human-lion interactions have dramatically increased during the last 20 years in Montana (Aune 1991) and in the U.S. and Canada (Beier 1992, Torres et al. 1996). Aune (1991) discovered that 36.5% of the negative interactions with lions in Montana involved livestock, and 63.5% involved humans and/or pets (predatory/aggressive behavior towards humans, 32.7%; nuisance situation, 15.4%; attacks on pets, 11.5%; and attacks on humans, 3.9%). The sex ratio of these problem lions was approximately equal, and most were in good condition. Two-year-old or younger lions were involved in 70% of these human-lions interactions, suggesting that most problems were caused by dispersing subadults. In the U.S. and Canada from 1890 until 1992, mountain lions caused 11 human deaths and at least 47 nonfatal attacks. Yearlings and underweight lions were most likely to attack, and victims were children who were usually alone (McBride and Ruth 1988, Beier 1991, Beier 1992).

Aune (1991) compiled trend data from lion harvest, animal damage complaints, and nonhunting mortality in Montana from 1971-1990 and concluded that increasing lion populations and expanding human populations were significant factors in the increasing human-lion interactions. Increased summer recreation could also be a contributing factor, as most human-lion encounters occurred between July and November and involved summer recreationists and fall hunters in lion habitat. Lions also preyed on pets accompanying humans or near residences. In California, pet depredation is rapidly increasing and reflects a radiation of human activities into lion habitat (Torres et al. 1996).

Habituation to humans - Habituation and food conditioning of lions were factors in several human-lion interactions in Montana and other western states. Gradual habituation begins with humans living and recreating in lion habitat and lions feeding on human refuse, pets, or natural prey near campgrounds and residences (McBride and Ruth 1988, Aune 1991). Lions near Boulder, Colorado, and Big Bend National Park, Texas, habituated to humans when natural prey concentrated near human activities (Halfpenny et al. 1991, Ruth 1991). Aune (1991) summarizes that changes in lion feeding behaviors may lead to humans as an alternative prey species. However, Beier (1992) stated that no substantial evidence exists to relate the increase in lion attacks to habituated lions.

Conclusions

As human populations and the pursuit of recreation continue to increase, lion-human interactions will probably also increase. Whether lion hunting regulations focus on the dispersing subadults in the human-lion habitat interface or control actions focus on specific problem lions, a proactive strategy adopted for humans recreating in lion habitat can also reduce these negative encounters. Education should continue to focus on controlling attractants in recreational areas, monitoring pet behaviors, and teaching appropriate aggressive responses to lion attacks (McBride and Ruth 1988, Aune 1991, Beier 1991, Murphy 1998).

Many believe that the presence of large carnivores, such as mountain lions, increases the recreational experience. We must also recognize the impacts of human activities on this species, such as the effects of hunting and other recreational activities on lion populations and their prey species, the increase of human-lion interactions, and most significantly, the potential habitat fragmentation and degradation through use of trails, roads, campsites, and other human developments. Additional research focusing on these objectives will provide specific knowledge to further decrease the impact of human activities on mountain lions.

Guidelines/Recommendations

1. Create and implement mountain lion management zones that would include: (a) no tolerance for lions in and near cities and towns; (b) intensively manage mountain lion populations, yet maintain sustainable populations balanced with public safety and livestock issues; (c) manage large blocks of undeveloped public land as wild landscape linkages to sustain mountain lion populations through less intensive management.
2. Minimize harvest of adult mountain lions, as adults are less likely to be involved in human-lion encounters, while emphasizing harvest of two- and three-year-old lions, in order to maintain social stability within the mountain lion community.
3. Avoid human encroachment into ungulate seasonal ranges so that mountain lions are able to sustain themselves without contact/conflict with humans.
4. Implement area and road closures and/or modify harvest regulations to prevent overharvest of lions in vulnerable habitats. In specified areas, access could be allowed for limited periods.
5. Restrict snowmobiles to designated routes and designated play areas; minimize snowmobile activity in and near big game winter ranges (mountain lion habitat) on public lands.
6. Require real estate brokers to provide "living with lions" literature to all prospective home buyers within mountain lion habitat.
7. Provide intensive education about living in lion country, proper techniques for minimizing lion-human conflicts, and the importance of keeping lions wild. Interactive, computer-based educational programs could be developed.
8. Encourage public participation in land use planning legislation and promote efforts to avoid development in critical wildlife habitats. Discourage hobby farmers and provide recommendations to county planners about the perils of raising hobby animals.
9. Press for authority to legally cite individuals who persist in contributing to situations that attract mountain lions.

Information Needs

1. Determine whether recreational activities on public lands are altering prey distribution or other life-cycle necessities for mountain lions so that lions are displaced from public lands onto private lands.
2. Establish a method to manage mountain lions based on population objectives rather than harvest trends.
3. Monitor lion management to determine if regional population objectives are being met.
4. Determine how different regional habitats influence productivity of individual mountain lion populations.
5. Evaluate the concept of a *zone management plan* (Logan and Sweanor 1999), and its application to Montana.
6. Determine the physiological implications of chase seasons on mountain lions (MFWP 1996).

CONCLUSIONS RELATIVE TO ALL CARNIVORES

In the absence of complete knowledge of habitat requirements of carnivores and their susceptibility to human disturbances, consideration should be geared toward requirements of the productive female segment of populations, including habitat and energy requirements associated with gestation, parturition and lactation. Male carnivores are characteristically wide-ranging and therefore more susceptible to direct human-caused mortality. Particular species of concern are those such as grizzly bear, wolverine, and lynx that are known to characteristically seek solitude for denning and rearing of young and have wide ranging movements.

Carnivore species differ in their susceptibility to human disturbance. The carnivores least sensitive to human disturbance are the generalists such as coyotes, red fox, raccoons, and skunks. Other species such as Canada lynx that are more specialized in their foraging strategy, may be particularly vulnerable to disturbances that compromise their winter foraging efficiency. More research is needed to document the magnitude of this potential effect. Potential impacts of dispersed and developed recreation projects and activities are variable and complex. For an outlined approach to these specific types of project analyses, refer to the Draft Canada Lynx Conservation Assessment and Strategy (BLM et al. 1999).

To analyze project effects on medium- to large-sized carnivores, it is particularly important to consider not only direct project impacts, but also potential impacts on a landscape basis in the context of connectivity, refugia, and metapopulations. For example, new groomed snowmobile trails will have immediate area effects; the next level to consider is the impact of all snowmobile trails within a large area (at least the size of a national park or forest) to delineate cumulative effects. Refugia (landscapes, generally wilderness or back-country, that are not readily subject to hunting, trapping, and frequent human disturbance) are recognized as necessary for persistence of forest carnivore populations by supporting source populations that can repopulate adjacent landscapes via dispersal and emigration.

In addition to the necessity to analyze impacts on carnivores at varying geographic scales, it is important to consider impacts specifically on biological elements, such as: productivity, mortality, movements, and dispersal. For an example of this approach, refer to the Draft Canada Lynx Conservation Assessment and Strategy (BLM et al. 1999).

Socio-economic considerations are important in the context of carnivore management. Some of these values include impact to domestic livestock operations and opportunities for trapping and hunting. Social values of wildlife, present new considerations for resource managers (Duda et al. 1998). Undoubtedly the fastest growing carnivore "use" is appreciation through viewing, photographing, and symbolic values.

With increasing human pressures for recreational opportunities, it is imperative to gain more information on carnivores so they can be managed in a context of species requirements, ecosystem (landscape) scale, and socio-economic values. In summary, these mid- to large-sized carnivores require large home ranges; they characteristically conduct wide-ranging movements, and exhibit specialized biological and habitat requirements. Because of these characteristics, they are particularly vulnerable to habitat fragmentation and alteration. Indicative of these circumstances is the proposed and/or federal listing of several of the mid- to large-sized carnivores under the ESA of 1973, as amended.

LITERATURE CITED

Aderhold, M. 1984. Montana's million dollar black bears. Montana Outdoors, Mt. Dept. Fish, Wildlife and Parks Publ. 15(2):6-10.
Allen, A. W. 1987. The relationship between habitat and furbearers. In: M. Novak, J.A. Baker, M.E. Obbard, comps., eds. Wild furbearer management and conservation in North America. North Bay, Ontario: Ontario Trappers Association. Pp: 164-179.
Almack, J. A. 1985. Grizzly bear habitat use, food habits, and movements in the Selkirk Mountains, northern Idaho. Pages 150-157 *in* G.P. Contreras and K.E. Evans, compilers. Proceedings of the Grizzly Bear Habitat Symposium. U.S. Forest Service General Technical Report INT-207.
Albert, D. M., and R. T. Bowyer. 1991. Factors related to grizzly bear-human interactions in Denali National Park. Wildlife Society Bulletin 19(3):339-349.
Anderson, A. E. 1983. A critical review of literature on puma (*Felis concolor*). Spec. Rep. No. 4. Colorado Div. Wildlife, Denver. 9pp.
Apps, C. D. 1999. Space-use, diet, demographics and topographic associations of lynx in the Southern Canadian Rocky mountains: a study. Chapter 12 in USDA Forest Service Gen. Tech. Rep. RMRS-GTR-30.
Archibald, N. J., R. Ellis, and A. N. Hamilton. 1987. Responses of grizzly bears to logging truck traffic in the Kimsquit River Valley, British Columbia. Int. Conf. on Bear Res. and Manage. 7:251-257.
Arthur, S. M., and W. B. Krohn. 1991. Activity patterns, movements, and reproductive ecology of fishers in southcentral Maine. Journal of Mammalogy 72: 379-385.
Arthur, S. M., W. B. Krohn, and J. R. Gilbert. 1989a. Home range characteristics of adult fishers. Journal of Wildlife Management 53: 674-679.
Arthur, S. M., W. B. Krohn, and J. R. Gilbert. 1989b. Habitat use and diet of fishers. Journal of Wildlife Management 53: 680-688.
Aubry, K. B., G. M. Koehler, and J. R. Squires. 1999. Ecology of Canada lynx in southern boreal forests. Chapter 13 in USDA Forest Service Gen Tech Rep. RMRS-GTR-30.
Aumiller, L., and C. Matt. 1994. Management of McNeil River State Game Sanctuary for viewing of brown bears. Int. Conf. Bear Res. and Manage. 9(1):51-61.
Aune, K. 1991. Increasing mountain lion populations and human-mountain lion interactions in Montana. Pages 86-94 *in* C. L. Braun, ed. Mountain Lion-Human Interaction Symp. Colo. Div. Wildl., Denver. 114pp.
Aune, K., and B. Brannon. 1987. East Front grizzly studies. Mt. Dept. Fish, Wildlife and Parks, Helena. 195pp.
Aune, K., and W. Kasworm. 1989. Final report: East Front grizzly studies. Mt. Dept. Fish, Wildlife, and Parks, Helena. 332 pp.
Aune, K., and P. Schladweiler. 1993. Wildlife laboratory annual report. Montana Department of Fish, Wildlife and Parks. Bozeman.
Aune, K., T. Stivers, and M. Madel. 1984. Rocky Mountain Front grizzly bear monitoring and investigation. Montana Department of Fish, Wildlife & Parks. Helena. 239pp.
Aune, K. E., M. J. Madel and C. L. Hunt. 1986. Rocky Mountain Front grizzly bear monitoring and investigation. Mont. Dept. Fish, Wildl. and Parks, Helena. 175pp.
Bailey, T. N., E. E. Bangs, M. F. Portner, J. C. Malloy and R. J. McAvinchey. 1986. An apparent overexploited lynx population on the Kenai Peninsula, Alaska. Journal of Wildlife Management 50: 279-289.
Ballard, W. B., J. S. Whitman, and C. L. Gardner. 1987. Ecology of an exploited wolf population in south-central Alaska. Wildlife Monographs 98.
Banci, V. A. 1987. Ecology and behavior of wolverine in Yukon. M.S. Thesis. University of British Columbia, Vancouver. 178 pages.
Banci, V. 1989. A fisher management strategy for British Columbia. Wildl. Bull. No. B-63; ISSN 0829-9560 Min. of Env., Victoria, British Columbia.
Banci, V.A. 1994. Wolverine. Pages 99-127 *in* L.R. Ruggiero, K.B. Aubry, S.W. Buskirk, L.J. Lyon and W.J. Zielinski, eds. The scientific basis for conserving forest carnivores, American marten, fisher, lynx, and wolverine in the western United States. USDA Forest Service Gen Tech Rep RM-254.
Banci, V. A., and A. S. Harestad. 1988. Reproduction and natality of wolverine *(Gulo gulo)* in Yukon. Ann. Zool. Fenn. 25: 265-270.
Banci, V., D. A. Demarchi, and W. R. Archibald. 1994. Evaluation of the population status of grizzly bears in Canada. Int. Conf. Bear Res. and Manage. 9(1):129-142.
Banfield, A. W. F. 1974. The mammals of Canada. Univ. of Toronto Press for National Museum of Natural Science and the National Museums of Canada. 438pp.

Bangs, E. E., and S. H. Fritts. 1996. Reintroducing the gray wolf to central Idaho and Yellowstone National Park. Wildlife Society Bulletin 24:402-413.

Barash, D. P. 1971. Cooperative hunting in the lynx. Journal of Mammology 52:480.

Barnhurst, D. 1986. Vulnerability of cougars to hunting. M.S. Thesis. Utah State Univ., Logan. 56pp.

Barnhurst, D., and F.G. Lindzey. 1989. Detecting female mountain lions with kittens. Northwest Science 63:35-37.

Barnes, V. G. 1994. Brown bear-human interactions associated with deer hunting on Kodiak Island. Int. Conf. Bear Res. and Management 9(1):63-73.

Beck, T. D. I. 1991. Black bears of west-central Colorado. Technical publication no. 39, Colorado Div. Wildlife. 86pp.

Beecham, J. J. 1980a. Some population characteristics of two black bear populations in Idaho. Int. Conf. Bear Res. and Manage. 4:201-204.

Beecham, J. J. 1980b. Population characteristics, denning, and growth patterns of black bears in Idaho. Ph.D. Thesis. Univ. Mont., Missoula. 101pp.

Beecham, J. J. 1983. Population characteristics of black bears in west central Idaho. J. Wildl. Manage. 47(2):405-412.

Beecham, J. J., and D. G. Reynolds. 1977. Home range activities and reproduction of black bears in west-central Idaho. *In:* Martinka, C. L., and K. L. McArthur (eds). Bears – Their biology and management. 4th International Conference on Bear Research and Management.

Beecham, J., and J. Rohlman. 1994. Idaho's Black Bear: A Shadow in the Forest. Idaho Dept. Fish and Game and the University of Idaho Press. Moscow, ID 245pp.

Beecham, J., and P. Zager. 1992. Black bear management plan 1992-2000. Idaho Dept. of Fish and Game, Boise. 51pp.

Beecham, J. L., D. G Reynolds, and M. G. Hornocker. 1983. Black bear denning activities and den characteristics in west-central Idaho. Int. Conf. Bear Res. and Manage. 5:79-86.

Beier, P. 1991. Cougar attacks on humans in the United States and Canada. Wildl. Soc. Bull. 19:403-412.

Beier, P. 1992. Cougar attacks on humans: an update and some further reflections. Proc. Vert. Pest Conf. 15:365-367.

Beier, P. 1993. Determining minimum habitat areas and habitat corridors for cougars. Conserv. Biol. 7:94-108.

Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitat. J. Wildl. Manage. 59:228-237.

Beier, P., and R. H. Barrett. 1993. The cougar in the Santa Ana Mountain Range, California. Final Rep., Orange City. Coop. Mt. Lion Study. Univ. California, Berkeley. 104pp.

Bekoff, M. 1982. Coyote. Pages 447-459 *in* J.A. Chapman and G.A. Felkhamer, editors. Wild Mammals of North America, Biology, Management and Economics. John Hopkins University Press, Baltimore, USA and London, England.

Belden, R. C., B. W. Hagedorn, and W. B. Frankenberger. 1991. Responses of translocated mountain lions to human disturbance (abstract). Page 26 *in* C.L. Braun, ed. Mountain Lion-Human Interaction Symp. Colo. Div. Wildl., Denver. 114pp.

Berrie, P. M. 1974. Ecology and status of the lynx in interior Alaska. Pages 4-41 in R.L. Eaton, ed. The world's cats. Vol. 1. World Wildlife Safari, Winston, OR.

Bider, J. R. 1962. Dynamics and the tempero-spatial relations of a vetebrate community. Ecology 43: 634-646.

Bittner, S. L. and O. J. Rongstad. 1984. Snowshoe hare and allies. Pages 146-163 *in* J. A. Chapman and G. A. Feldhammer, eds. Wild mammals of North America. John Hopkins University Press, Baltimore, MD.

Black-footed Ferret Recovery Implementation Team (BFRIT). 1998. Black-footed ferret - return of a native. Black-footed Ferret Recovery Implementation Team and Arizona Game & Fish Dept. Phoenix, AZ. 8p.

Blanchard, B. M. 1983. Grizzly bear-habitat relationships in the Yellowstone area. Int. Conf. on Bear Res. and Manage. 5:118-123.

Bowen, W. D. 1982. Home range and spatial organization of coyotes in Jasper national Park, Alberta. Journal of Wildlife Management. 46:201-216.

Boyd, D. K., and D. H. Pletscher. 1999. Characteristics of dispersal in a colonizing wolf population in the central Rocky Mountains. Journal of Wildlife Management. In press.

Boyd, D., D. H. Pletcher, and W. Brewster. 1993. Evidence of wolves burying dead wolf pups. Canadian Field-Naturalist 107:230-231.

Boyd, D. K., P. Paquet, S. Donelon, R. R. Ream, D. H. Pletscher, and C. White. 1995. Transboundary movements of a recolonizing wolf population in the Rocky Mountaims. Pages 135-140 *in* L. N. Carbyn, D. Siep, and S. H. Fritts, editors. Ecology and conservation of wolves in a changing world. Canadian

Circumpolar Institute, Edmonton, Alberta, Canada.
Boyd-Heger, D. K. 1997. Dispersal, genetic relationships, and landscape use by colonizing wolves in the Central Rocky Mountains. Dissertation, University of Montana, Missoula, Montana, USA.
Brainerd, S. M. 1985. Reproductive ecology of bobcats and lynx in western Montana. University of Montana, Missoula.
Brand, C. J., and L. B. Keith. 1979. Lynx demography during a snowshoe hare decline in Alberta. Journal of Wildlife Management 43:827-849.
Brannon, R. D. 1984. Influence of roads and developments on grizzly bears in Yellowstone National Park. USDI Interagency Grizzly Bear Study Team, Bozeman, Montana. 52pp.
Bray, O. E., and V. G. Barnes, Jr. 1967. A literature review on black bear populations and activities. U.S. Nat'l. Park Serv. & Colo. Coop. Wildl, Res. Unit, Ft. Collins, 34 pp.
Brocke, R. H., K. A. Gustafson, and L. B. Fox. 1992. Restoration of large predators: potential and problems. In: Decker, D.J., M.E. Krasny, G.R. Goff, C.R. Smith, D.W. Gross, eds. Challenges in the conservation of biological resources, a practitioner's guide. Boulder, CO. Westview Press: 303-315.
Brody, A. J., and M. R. Pelton. 1989. Effects of roads on black bear movements in western North Carolina. Wildl. Soc. Bull. 17(1):5-10.
Brown, D. E. 1985. The grizzly in the southwest. University of Oklahoma Press, Norman. 274pp.
Brown, J. 1990. Region One annual black bear report. Montana Dept. Fish, Wildlife and Parks.
Bunnel, F. L., and D. E. N. Tait. 1981. Population dynamics of bears – implications. Pages 75-98 *in* C. W. Fowler and T. D. Smith, eds. Dynamics of large mammal populations. John Wiley & Sons. New York.
Bunnel, F. L., and D. E. N. Tait. 1985. Mortality rates of North American bears. Arctic 38:318-323.
Burt, W. H. and R. P. Grossenheider. 1976. A field guide to the mammals. Houghton Mifflin, Boston. 289pp.
Buskirk, S. W. 1991. Habitat ecology and ecologists, what are we doing? Symposium on the Biology and Management of Martens and Fishers. Laramie, Wyoming.
Buskirk, S. W., and R. A. Powell. 1984. Habitat ecology of fishers and American martens. In: S. W. Buskirk, A. S. Harestad, and M. G. Raphael, comps., eds. Martens, sables, and fishers: biology and conservation. Cornell University Press. Ithaca, New York. Pp: 283-296.
Buskirk, S. W. and L. L. McDonald. 1989. Analysis of variability in home-range size of the American marten. Journal of Wildlife Management 53: 997-1004.
Buskirk, S. W. and L. F. Ruggiero. 1994. American marten. Pages 7-37 *in* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski (eds). The scientific basis for conserving forest carnivores: American marten, fisher, lynx and wolverine in the western United States. USDA For. Serv. Rocky Mt. For. And Range Exp. Stn., Gen. Tech Rep. RM-254, Fort Collins, CO.
Buskirk, S. W., and Powell, R. A. 1994. Habitat ecology of fishers and American martens Pages 283-296 *in* Buskirk, S. W.; Harestad, A. S. ; Raphael, M. G., comps., eds. Martens, sables and fishers: biology and conservation. Ithica, NY. Cornell University Press.
Buskirk, S. W., S. C. Forrest and M. G. Raphael. 1989. Winter resting site ecology of marten in the central Rocky Mountains. J. Wildl. Manage. 53:191-196.
Buskirk, S. W., L. F. Ruggiero and C. J. Krebs. 1999. Habitat fragmentation and Interspecific competition: implications for lynx conservation. Chapter 4 in USDA Forest Service Gen Tech Rep. RMRS-GTR-30.
Carbyn, L. N. 1974. Wolf predation and behavioural interactions with elk and other ungulates in an area of high prey diversity. Dissertation, University of Toronto, Toronto, Ontario, Canada.
Carney, D. W. 1985. Population dynamics and denning ecology of black bears in Shenandoah National Park, Virginia. M.S. Thesis. Virginia Polytech. Inst. and State Univ., Blacksburg. 84pp.
Case, T. J., and M. R. Gilpin. 1974. Interference competition and niche theory. Proceedings of the National Academy of Sciences 71: 3073-3077.
Chapman, R. C. 1977. The effects of human disturbance on wolves (*Canis lupus*). Thesis, University of Alaska, Fairbanks, Alaska, USA.
Chester, J. M. 1980. Factors influencing human-grizzly bear interactions in a backcountry setting. Pages 351-357 *in* Martinka, C.J. and K. L. McArthur, editors. Forth Int. Conf. on Bear Res. and Manage. 1977 Feb; Kalispell, Montana. Bear Biology Association.
Coffin, K. W. 1994. Population characteristics and winter habitat selection by pine marten in southwest Montana. M.S. thesis. Montana State University. Bozeman. 94pp.
Copeland, J. P., and C. L. Harris. 1994. Wolverine ecology and habitat use in central Idaho. Progress report, Idaho Dept., Fish and Game. 29pp.

Copeland, J. P. 1996. Biology of the wolverine in central Idaho. M.S. thesis. University of Idaho. Moscow. 138pp.
Craighead, J. J. 1980. A proposed delineation of critical grizzly bear habitat in the Yellowstone region. Bear Biololgy Association Monograph Series No. 1 20pp.
Craighead, F. C. and J. J. Craighead. 1969. Radiotracking of grizzly bears in Yellowtone National Park, Wyoming, 1964. Pages 35-43 *in* P. H. Oehser, editor. National Geographic Society Research Reports, 1964. National Geographic Society, Washington D.C.
Craighead, F. C., and J. J. Craighead. 1972. Grizzly bear prehibernation and denning activities as determined by radiotracking. Wildlife Monographs 32. 35pp.
Darling, L. M. 1987. Habitat use by grizzly bear family groups in interior Alaska. Int. Conf. on Bear Res. and Manage. 7:169-178.
Day, G. L. 1981. The status and distribution of wolves in the northern Rocky Mountains of the United States. thesis, University of Montana, Missoula.
deVos, A. 1951. Recent findings in fisher and marten ecology and management. In: Transactions of 16th North American wildlife Conference 16:498-507.
Dood, A., R. D. Brannon, and R. D. Mace. 1986. Final programmatic environmental impact statement, the grizzly bear in northwestern Montana. Mont. Dept. of Fish, Wildl. and Parks, Helena. 287pp.
Douglas, C. W. and M. A. Strickland. 1987. Fisher. Chapt. 40, p. 511-529. *In*: M. Novak et al. (Eds). Wild Furbearer Management and Conservation in North America. Ontario Ministry of Natural Resources, Toronto. 1150 pp.
Douglass, R. J. and J. Ernst. 1985. Impacts of vehicle traffic on coyote movement in western Colorado. Pages 296-300 *in* R.D. Comer editor. Issues and Technology in the Management of Impacted Western Wildlife.

Duda, M. D., S. J. Bissell, and K. C. Young, eds. 1998. Wildlife and the American mind: Public opinion on and attitudes toward fish and wildlife management. Responsive Management, Harrisburg, Virginia. 804 pages.
DuBrock, C. W. 1980. An analysis of Virginia black bear population dynamics. M.S. Thesis. Virginia Polytechnic Institute and State University, Blacksburg, VA. 115 pp.
Eagle, T. C., and M. R. Pelton. 1983. Seasonal nutrition of black bears in the Great Smoky Mountains National Park. Int. Conf. Bear Res. and Management. 5:94-101.
Eberhardt, L. L. and R. R. Knight. 1996. How many grizzlies in Yellowstone? J. Wildl. Manage. 60(2):416-421.
Edge, W. D., C. L. Marcum, and S. L. Olson. 1985. Effects of logging activities on home-range fidelity of elk. J. Wildl. Manage. 49:741-744.
Eibl-Eibesfeldt, I. 1970. Ethology: the biology of behavior. New York: Holt, Rinehart, and Winston. 530pp.
Elgmork, K. 1978. Human impact on a brown bear population (*Ursus arctos* L.). Biological Conservation 13(2):81-103.
Elowe, K. D., and W. E. Dodge. 1989. Factors affecting black bear reproductive success and cub survival. J. Wildl. Manage. 53(4):962-968.
Erickson, A.W., J. Nellow, and G. A. Petrides. 1964. The black bear in Michigan. Michigan State Univ. Agr. Exp. Sta. Res. Bull. 4. 102 pp.
Fager, C.W. 1991. Harvest dynamics and winter habitat use of the pine marten in southwest Montana. Montana State University, Bozeman. M.S. Thesis. 73 pages.
Folk, G. E., Jr., 1967. Physiological observations of subarctic bears under winter den conditions. Pages 75-85 *in* K. Fisher, ed. Mammalian Hibernation. Am. Elsvier Publ. Co., NY NY.
Fredrickson, R. J. 1990. The effects of disease, prey fluctuation and clear cutting on American marten in Newfoundland, Canada. M.S. thesis, Utah State Univ., Logan, UT. 76pp.
Fritts, S. H. 1983. Record dispersal by a wolf from Minnesota. Journal of Mammalogy 64:166-167.
Fritts, S. H., E. E. Bangs, and J. F. Gore. 1994. The relationship of wolf recovery to habitat conservation and biodiversity in the northwestern United States. Landscape and Urban Planning 28:23-32.
Fritts, S. H., and L. N. Carbyn. 1995. Population viability, nature reserves, and the outlook for gray wolf conservation in North America. Restoration Ecology 3:26-38.
Fritts, S. H., E. E. Bangs, J. A. Fontaine, M. R. Johnson, E. D. Koch, and J. R. Gunson. 1997. Planning and implementing a reintroduction of wolves to Yellowstone National Park and central Idaho. Restoration Ecology 5:7-27.
Fuller, T. K. 1989. Population dynamics of wolves in north-central Minnesota. Wildlife Monographs 105.
Gabrielsen, G. W., and E. N. Smith. 1995. Physiological responses of wildlife to disturbance *in* Knight and Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C. 372pp.

Garner, C. L. 1985. The ecology of wolverines in southcentral Alaska. M.S. Thesis, Univ. Alaska-Fairbanks. 82pp.
Garshelis, D. L. 1990. Monitoring effects of harvest on black bear populations in North America: a review and evaluation of techniques. East. Workshop Black Bear Res. and Manage. 10:120-144.
Garshelis, D. L. 1994. Density-dependent population regulation of black bears. Pages 3-14 *in* M. Taylor, ed. Density-dependent population regulation in black, brown, and polar bears. Int. Conf. Bear Res. and Manage. Monogr. Series No. 3. 43pp.
Gese, E. M., O. J. Rongstad, and W. R. Mytton. 1988a. Home range and habitat use of coyotes in southeastern Colorado. Journal of Wildlife Management. 52:640-646.
Gese, E. M., O. J. Rongstad, and W. R. Mytton. 1988b. Relationship between coyote group size and diet in southeastern Colorado. Journal of Wildlife Management. 52:647-653.
Gese, E. M., O. J. Rongstad, and W. R. Mytton. 1989. Population dynamics of coyotes in southeastern Colorado. Journal of Wildlife Management. 53:174-181
Giddings, B. 1995. Statewide furbearer program annual management and harvest report, 1993-1994, Montana. Montana Department of Fish, Wildlife and Parks, Helena. 51pp.
Gilbert, B. K. 1989. Behavioural plasticity and bear-human conflicts. Pages 1-8 *in* M. Bromley, editor. Bear-people conflicts: Proceedings of a symposium on management strategies; 1987 Apr 6 - 1987 Apr 10; Yellowknife, Northwest Territories, Canada. Yellowknife: Northwest Territories Department of Renewable Resources.
Goyal, S. M., L. D. Mech, R. A. Rademacher, M. A. Kahn, and U. S. Seal. 1986. Antibodies against canine parvovirus in wolves in Minnesota: a serological study 1975-1985. Journal of American Veterinary Medical Association 189:1092-1094.
Graber, D. M. 1982. Ecology and management of black bears in Yosemite National Park. Coop. Parks Studies Unit, Univ. Calif Davis, Tech, Rep. No. 5. 206pp.
Graber, D. M., and M. White. 1982. Black bear food habits in Yosemite National Park. Int. Conf. Bear Res. and Manage. 5:1-9.
Graham, D. C. 1978. Grizzly bear distribution, use of habitats, food habits, and habitat characterization in Pelican and Hayden Valleys, Yellowstone National Park. M.S. Thesis. Montana State University, Bozeman. 89pp.
Greer, S. Q. 1987. Home range, habitat use, and food habits of black bears in south-central Montana. M.S. thesis. Montana State Univ., Bozeman. 91 pp.
Grenfell, W. E., and A. J. Brody. 1983. Black bear habitat use in the Tahoe National Forest, California. *In:* Zager, P. (ed.). 1986 Bears – Their biology and management. 6th Int. Conf on Bear Research and Management.
Gunther, K. 1994. Bear management in Yellowstone National Park. Int. Conf. Bear Res. and Manage. 9(1):549-560.
Haight, R. G., D. J. Mladenoff, and A. P. Wydeven. 1998. Modeling disjunct gray wolf populations in semi-wild landscapes. Conservation Biology 12:879-888.
Halfpenny, J. C., M. R. Saunders, and K. A. McGrath. 1991. Human-lion interactions in Boulder County, Colorado: past, present, and future. Pages 10-16 *in* C.L. Braun, ed. Mountain Lion-Human Interaction Symp. Colo. Div. Wildl., Denver. 114pp.
Hall, E. R. 1942. Gestation period of the fisher with recommendation for the animals' protection in California. California Fish and Game 28:143-147.
Hall, E.R. 1981. The mammals of North America. 2nd edition. John Wiley & Sons. New York, New York. 1181 pages.
Hamlin, K. L. 1997. Survival and home range fidelity of coyotes in Montana: implications for control. Intermountain Journal of Science 3(2/3):62-72.
Hamer, J. D., and S. Herrero, editors. 1983. Ecological studies of the grizzly bear in Banff National Park. Final Rep. For Parks Canada. Contract WR 4-80. Unvi. of Calgary, Alberta. 303pp.
Hamer, J. D., and S. Herrero. 1987. Grizzly bear food and habitat in the front ranges of Banff National Park, Alberta. Int. Conf. on Bear Res. and Manage 7:199-213.
Hamer, J. D., S. Herrero, and R. T. Ogilvie. 1977. Ecological studies of the Banff National Park grizzly bear. Proj. Report 1978. 239pp.
Hamilton, W. J., Jr. 1943. Mammals of Eastern United States. Comstock Publishing Co., Ithaca, NY. 432pp.
Hamilton, R. J., and R. L. Marchington. 1980. Denning and related activities of black bears in the coastal plain on North Carolina. Int. Conf. Bear Res. and Manage 4:212-126.
Harding, L. and J. A. Nagy. 1980. Responses of grizzly bears to hydrocarbon exploration on Richards Island, Northwest Territories, Canada. Int. Conf. Bear Res. and Manage 4:277-280.
Harlow, H. J., F. G. Lindzey, W. D. VanSickle, and W. A. Gern. 1992. Stress response of cougars to nonlethal pursuit by hunters. Can. J. Zool. 70(1):136-139.

Harris, R. B. 1985. Results of the workshop on grizzly bear population genetics. Sponsored by the Office of the Grizzly Bear Recovery Coordinator, U.S. Fish and Wildl. Serv., Missoula, MT. 8pp.
Harrison, D. J., J. A. Bissonett, and J. A. Sherburne. 1989. Spatial relationship between coyotes and red foxes in eastern Maine. Journal of Wildlife Management. 53:181-183.
Hart, J. 1999. Keeping the wolf from the door. International Wolf, Summer 1999:3-6.
Hash, H. S. 1987. Wolverine. In: M.Novak, J.A. Baker, and M.E. Obbard, comps. eds. Chapter 43, Wild furbearer management and conservation in North America. Toronto, Ontario ministry of natural resources. Pp: 575-585.
Hawley, V. D., and F. E. Newby. 1957. Marten home ranges and population fluctuations. J. Mammal. 38:174-184.
Heinemeyer, K. S. 1993. Temporal dynamics in the movements, habitat use, activity and spacing of reintroduced fishers in northwestern Montana. M.S. thesis, Univ. of Montana, Missoula. 154pp.
Heinemeyer, K. S., and J. Jones. 1994. Fisher biology and management in the western United States: A literature review and adaptive management strategy. Prepared for the USDA Forest Service Northern Region and the Interagency Forest Carnivore Working Group, Missoula, Montana. 109pp.
Hellgren, E. 1998. Physiology of hibernation in bears. Ursus 10:467-477.
Henderson, F. R., P. F. Springer, and R. Adrian. 1974. The black-footed ferret in South Dakota. SD Dept. of Game, Fish and Parks. Pierre, SD. Technical Bulletin Number 4.
Herrero, S. 1978. A comparison of some features of the evolution, ecology and behavior of black and grizzly/brown bears. Carnivore 1(1):7-17.
Hererro, S. 1979. Black bears: the grizzly's replacement? Pages 179-195 *in:* D. Burke (ed.). The black bear in modern North America. Proc. Workshop on Manage. Biol. Of North Am. Black Bear, Feb. 17-29, 1997. Kalispell, MT. Boone and Crockett Club and Campfire Club of America.
Herrero, S. 1989. The role of learning in some fatal grizzly bear attacks on people. Pages 9-14 *in* M. Bromley, editor. Bear-people conflicts: Proceedings of a symposium on management strategies; Apr 6 - Apr 10, 1987; Yellowknife, Northwest Territories, Canada. Yellowknife: Northwest Territories Department of Renewable Resources.
Hilman, C. N. 1968. Field observations of black-footed ferrets in South Dakota. Trans. North Am. Wildl. Nat. Res. Conf. 33:433-443. As cited in Svendsen 1990.
Hines, T. D., and R. M. Case. 1991. Diet, home range, movements, and activity patterns of swift fox in Nebraska. Prairie Naturalist. 23(3):131-138.
Hodges, K. E. 1999. The ecology of snowshoe hares on northern boreal forests, Chapters 6-7 in USDA Forest Service Gen. Tech. Rep., RMRS-GTR-30.
Hodgson, R. G. 1937. Fisher farming. Fur Trade Journal of Canada.
Hoffman, R. S., P. L. Wright, and R. E. Newby. 1969, The distribution of some mammals in Montana. I. Mammals other than bats. J. Mammalogy 50:579-604.
Hornocker, M. G., and H. S.Hash. 1981. Ecology of the wolverine in northwestern Montana. Can. J. Zool. 59:1286-1301.
Hugie, R. D. 1982. Black bear ecology and management in the northern conifer-deciduous forests of Maine. Ph.D. Thesis, Univ. Mont., Missoula, MT. 203pp.
Huggard, D. J. 1993. Prey selectivity of wolves in Banff National Park, I. Age, sex, and condition of elk. Canadian Journal of Zoology 71:130-139.
Interagency Grizzly Bear Committee (IGBC). 1986. Interagency grizzly bear guidelines. Interagency Grizzly Bear Committee. 100pp.
Interagency Grizzly Bear Committee (IGBC). 1987. Grizzly bear compendium. Interagency Grizzly Bear Committee and National Wildlife Federation, Washington D.C. 540pp.
Irwin, L. L., and F. M. Hammond. 1985. Managing black bear habitats for food items in Wyoming. Wildl. Soc. Bull. 13:477-483.
Jacobs, M. J. and C. A. Schloeder. 1992. Managing brown bears and wilderness recreation on the Kenai Peninsula, Alaska, USA. Environmental Management 16(2):249-54.
Jacoby, M. E., G. V. Hilderbrand, C. Servheen, C. C. Schwartz, S. M. Arthur, T. A. Hanley, C. T. Robbins, and R. Michener. 1999. Trophic relations of brown and black bears in several western North American ecosystems. Journal of Wildlife Management 63(3):921-929.
Jalkotzy, M. and I. Ross. 1995. Cougar responses to human activity at Sheep River, Alberta. Arc. Wildl. Serv. Ltd, Calgary. 31pp.
Jensen, W. F., T. K. Fuller, and W. L. Robinson. 1986. Wolf, *Canis lupus*, distribution on the Ontario-Michigan border near Sault Ste. Marie. Canadian Field-Naturalist 100:363-366.
Jimenez. M. 1995. Tolerance and respect help Ninemile wolves recover. International Wolf 5:18-19.

Johnson, K. G., and M. R. Pelton. 1980. Environmental relationships and the denning period of black bears in Tennessee. J. Mammal 61(4):653-660.
Jones, J. L. 1991. Habitat use of fisher in northcentral Idaho. M. Sc. Thesis, Univ. of Idaho, Moscow. 147pp.
Jones, L. L. C., and M. G. Raphael. 1991. Ecology and management of marten in fragmented habitats of the Pacific Northwest. Unpubl. Rep. USDA Forest Service, Pacific Northwest Res. Stn., Forest Sciences Laboratory, Olympia, WA. 36pp.
Jonkel, C. J., and R. P. Weckwerth. 1963. Sexual maturity and implantation of blastocysts in the pine marten. J. Wildl. Manage 27(1):93-98.
Jonkel, C. J., and I. McT. Cowan. 1971. The black bear in the spruce-fir forest. Wildl. Monogr. 27. 57pp.
Jope, K. L. 1985. Implications of grizzly bear habituation to hikers. Wildlife Society Bulletin 13(1):32-7.
Joslin, P. W. B. 1966. Summer activities of two timber wolf (*Canis lupus*) packs in Algonquin Park. Thesis, University of Toronto, Toronto, Ontario, Canada.
Judd, S. L., R. R. Knight, and B. M. Blanchard. 1986. Denning of grizzly bears in the Yellowstone National Park area. Int. Conf. on Bear Res. and Manage. 6:111-117.
Kasworm, W. F., and G. Brown. 1983. Cabinet Mountains Grizzly Bear Study June-December 1983 Annual Report. Mt. Dep. Fish, Wildl. and Parks. Helena, MT. 16pp.
Kasworm, W. F., and T. L. Manley. 1988. Grizzly bear and black bear ecology in the Cabinet Mountains of northwestern Montana. Montana Fish, Wildlife and Parks. Helena. 122 pp.
Kasworm, W. F., and T. L. Manley. 1990. Road and trail influences on grizzly bears and black bears in northwest Montana. Int. Conf. on Bear Res. and Manage. 8:79-84.
Kasworm, W. F., and T. J. Thier. 1991. Cabinet-Yaak ecosystem grizzly bear and black bear research 1990 progress report. U.S. Dept. Inter., Fish and Wildl. Serv. Missoula, MT. 53 pp.
Keith, L. B. 1963. Wildlife's ten-year cycle. University of Wisconsin Press, Wisconsin, WI.
Kellert, S. R., and M. O. Westervelt. 1982. Historical trends in American animal use and perception. N. Amer. Wildl. Natur. Res. Conf., Trans. 47:649-664.
Kelly, G. M. 1977. Fisher (Martes pennanti) biology in the white mountain national forest and adjacent areas. University of Massachusetts, Amherst. Ph.D. Thesis. 178 pages.
Kemp, G. A. 1972. Black bear population dynamics at Cold Lake, Alberta, 1968-1970. Int. Conf. Bear Res. and Manage. 3:26-31.
Kemp, G. A. 1976. The dynamics and regulation of black bear *(Ursus americanus)* populations in northern Alberta. Int. Conf. Bear Res. and Manage. 3:191-197.
Kendall, K. C. 1983. Use of pine nuts by grizzly and black bears in the Yellowstone area. Int. Conf. Bear Res. and Manage. 5:166-173.

Kendall, K. C. 1986. Grizzly and black bear feeding ecology in Glacier National Park, Montana. U.S.D.A. Glacier National Park. 42pp.
Kilgore. D. L. 1969. An ecological study of the swift fox (*Vulpes velox*) in the Oklahoma panhandle. American Midland Naturalist 81:512-534.
Knight, R. L., and D. N. Cole. 1995. Wildlife responses to recreationists *in* Knight and Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C. 372pp.
Knight, R. L., and K. J. Gutzwiller. 1995. Wildlife and recreation: Coexistence through management and research. Island Press. Washington, D.C. 372 pages.
Knight, R. L., and S. A. Temple. 1995. Origin of wildlife responses to recreationists. Pages 81-91 *in* Knight and Gutzwiller, eds. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, D.C. 372pp.
Knight, R. R., J. Basile, K. Greer, S. Judd, L. Oldenburg, and L. Roop. 1978. Yellowstone grizzly bear investigations. Annual report of the Interagency Study Team, 1977. U.S.D.I., Interagency Grizzly Bear Study Team, Bozeman, MT. 107pp.
Knight, R. R., B. Blanchard, and D. Mattson. 1984. Movements and Habitat Use of The Yellowstone Grizzly Bear. U.S.D.I., Interagency Grizzly Bear Study Team, Bozeman, MT. 177pp.
Knowlton, F. F. 1972. Preliminary interpretations of coyote population mechanics with some management implications. Journal of Wildlife Management 36:369-382.
Koch, D. B. 1983. Population, home range and denning characteristics of black bears in Placer County, California. M.S. Thesis. Cal. State Univ., Sacramento. 71pp.
Koehler, G. M. 1990. Population and habitat characteristics of lynx and snowshoe hares in North-central Washington. Canadian Journal of Zoology 68:845-851.
Koehler, G. M., and M. G. Hornocker. 1977. Fire effects on marten habitat in the Selway-Bitterroot Wilderness. J. Wildl. Manage. 41:500-505.

Koehler, G. M., and M. G. Hornocker. 1991. Seasonal resource use among mountain lions, bobcats, and coyotes. Journal of Mammalogy. 72:391-396.
Koehler, G. M., and K. B. Aubry. 1994. Lynx. Pages 74-98 *in* L.F. Ruggiero, K.B. Aubrey, S.W. Buskirk, S. W., L. J. Lyon and W.J. Zielinski (eds) The scientific basis for conserving forest carnivores: American marten, fisher, lynx and wolverine in the western United States. USDA For, Serv. Gen. Tech. Rep. RM-254.
Koehler, G. M., M. G. Hornocker, and H. S. Hash. 1979. Lynx movements and habitat use in Montana. Canadian Field-Naturalist 93(4):441-442.
Koford, C. B. 1968. Status of the grizzly bear in Chihuahua, Mexico. Report to A. S. Leopold, University of California, Berkeley.
Koford, C. B. 1969. The last of the Mexican grizzly bear. International Union for the Conservation of Natural Resources Bulletin 21(2):95.
Kohn, B. E. 1982. Status and management of black bears in Wisconsin. Wisconsin Dept. Natural Resources Technical Bulletin 129. 31pp.
Kozlov, V. 1964. The wolf. Hunting and Hunting Economy 9:18-20.
Kunkel, K. E. 1997. Predation by wolves and other large carnivores in northwestern Montana and southeastern British Columbia. Dissertation, University of Montana, Missoula, MT
Laing, S. P. and F. G. Lindzey. 1993. Patterns of replacement of resident cougars in southern Utah. J. Mammal. 74:1056-1058.
Laberee, E. E. 1941. Breeding and reproduction in furbearing animals. Fur Trade Journal of Canada.
LeCount, A. L. 1977. Some aspects of black bear ecology in the Arizona chaparral. *In:* Martinka, C. L. and K. L. McArthur (eds). 1980. Bears – Their biology and management. 4th International Conference on Black Bear Research and Management.
LeCount, A. L. 1982. Characteristics of a central Arizona black bear population. J. Wildl. Manage. 46(4):861-868.
Le Count, A. L. 1983. Denning ecology of black bears in central Arizona. Int. Conf. Bear Res. and Manage. 5:71-78.
LeCount, A. L. 1986. Causes of black bear mortality. Arizona Game and Fish Dept. Phoenix, AZ 75082
LeCount, A. L. 1987. Causes of black bear cub mortality. Int. Conf. Bear Res. and Manage. 7:75-82.
Leopold, A. S. 1967. Grizzlies of the Sierra del Nido. Pacific Discovery 20(5):30-32.
Lewis, L., and C. R. Wenger. 1998. Idaho's Canada lynx: pieces of the puzzle. Idaho Bureau of Land Management, Technical Bulletin no. 98-1.21 pp.
Lindzey, F.G. 1981. Denning dates and hunting seasons for black bears. Wildl. Soc. Bull. 9(3):212-216.
Lindzey, F. G., and E. C. Meslow. 1977. Home range and habitat use by black bears in Oregon (1971-1974). Int. Conf Bear Res. and Manage. 4:213-219.
Lindzey, F.G., and E. C. Meslow. 1980. Harvest and population characteristics of black bears in Oregon (1971-1974). Int. Conf. Bear Res. and Manage. 4:213-219.
Lindzey, F. G., K. R. Barber, R. D. Peters, and E. C. Meslow. 1986. Responses of a black bear population to a changing environment. Int. Conf. Bear Res. and Manage. 6:57-63.
Litvaitis, J. A. 1992. Niche relations between coyotes and sympatric Carnivora. Pages 73-85 *in* A. H. Boer, editor. Ecology and management of the eastern coyote. University of New Brunswick Wildlife Research Unit, Fredericton, NB.
Logan, K. A., and L. L. Sweanor. 1999. Cougar management in the west: New Mexico as a template. Hornocker Wildlife Institute. Moscow, Idaho. 10pp.
Logan, K. A., L. L. Irwin, and R. Skinner. 1986. Characteristics of a hunted mountain lion population in Wyoming. J. Wildl. Manage. 50:648-654.
Logan, K. A., L. L. Sweanor, T. K. Ruth, and M. G. Hornocker. 1996. Cougar of the San Andres Mountains, New Mexico. Final Rep., Project W-128-R. New Mexico Dep. Game & Fish, Santa Fe. 280pp.
Lyon, L. J. 1979. Habitat effectiveness for elk as influenced by roads and cover. J. For. 77:658-660.
Mace, R. D., and G. N. Bissell. 1985. Grizzly bear food resources in the flood plains and avalanche chutes of the Bob Marshall Wilderness, Montana. Pages 78-91 *in* G. P. Contreras and K. E. Evans, compilers. Proceedings of the Grizzly Bear Habitat Symposium. U.S. Forest Service General Technical Report INT-207.
Mace, R. D., and J. S. Waller. 1996. Grizzly bear distribution and human conflicts in Jewel Basin Hiking Area, Swan Mountains, Montana. Wildlife Society Bulletin 24(3):461-467.
Mace, R., and J. Waller. 1997. Final Report: grizzly bear ecology in the Swan Mountains, Montana. Montana Fish, Wildlife and Parks, Helena, MT. 191pp.
Mace, R. D., and J. S. Waller. 1998. Demography and population trend of grizzly bears in the Swan Mountains, Montana. Conservation Biology 12(5):1005-1016.

Mace, R. D., T. L. Manley, and S. Riley. 1992. Grizzly bear response to forest road densities and timber management in a multiple use environment, research update. Mont. Dept. of Fish, Wildl. and Parks, Kalispell. 17pp.

Mace, R. D., J. S. Waller, T. L. Manley, L. J. Lyon, and H. Zuuring. 1996. Relationships among grizzly bears, roads and habitat in the Swan Mountains, Montana. Journal of Applied Ecology 33:1395-1404.

Mack, J. A. 1986. Ecology of black bears on the Beartooth Face, south-central Montana. M.S. Thesis, Montana State Univ., Bozeman, MT. 119pp.

Mack, J. A. 1990. Black bear dens in the Beartooth Face, south-central Montana. Int. Conf. Bear Res. and Manage. 8:273-277.

Madel, M. J. 1996. Rocky Mountain Front grizzly bear management program, four-year progress report, 1991-1994. Mont. Dept. Fish, Wildl. and Parks, Great Falls. 80pp.

Madel, M. J., T. Manley, D. Carney, S. Gniadek, A. Soukkala, J. Jonkel, and T. Wittinger. (Compiled by). 1998. Grizzly bear-human conflicts and confontations in the Northern Continental Divide Ecosystem, 1998. Draft Summary. Unpublished Report. Mont. Dept. Fish, Wildl. and Parks, Great Falls. 1pp.

Maehr, D. S. 1990. Florida panther movements, social organization, and habitat utilization. Final Rep. Florida Game and Fresh Water Fish Comm., Tallahassee. 159pp.

Maehr, D. S., E. D. Land, and M. E. Roelke. 1991. Mortality patterns of panthers in Southwest Florida. Proc. Annual Conf. Proc. Annu. Conf. Southeast Fish and Wildl. Agencies 45:201-207.

Magoun, A. J. 1985. Population characteristics, ecology and management of wolverines in northwestern Alaska. Ph.D. Thesis, University of Alaska, Fairbanks. 197 pages.

Manley, T. L. 1997. Grizzly bear management specialist report, Western Montana, (July 1, 1996-June 30, 1997). Mont. Fish, Wildl. and Parks, Kalispell. 14pp.

Manley, T. L., and R. D. Mace. 1992. Grizzly bear habitat use and disturbance studies: South Fork of the Flathead River. Progress report for 1991. Mont. Dept. of Fish, Wildl. and Parks, Kalispell. 41pp.

Manville, A. M. II. 1983. Human impact on the black bear in Michigan's lower peninsula. Int. Conf. Bear Res. and Manage. 5:20-33.

Martin, P. A. 1979. Productivity and taxonomy of the *Vaccinium globulare, V. membranaceum* complex in Western Montana. M. S. Thesis. University of Montana, Missoula. 136pp.

Martin, P. 1983. Factors influencing globe huckleberry fruit production in northwestern Montana. Int. Conf. Bear Res. and Manage. 5:159-165.

Martinka, C. J. 1971. Status and management of grizzly bears in Glacier National Park, Montana. Trans. North. Am. Wildl. and Nat. Resour. Conf. 36:312-322.

Martinka, C. J. 1972. Habitat relationships of grizzly bears in Glacier National Park. Prog. Rep. 1972. USDI, National Park Service. Glacier National Park. Montana. 19pp.

Mattson, D. J. 1990. Human impacts on bear habitat use. Int. Conf. Bear Res. and Manage. 8:33-56.

Mattson, D. J. 1993. Background and proposed standards for managing grizzly bear habitat security in the Yellowstone Ecosystem. Cooperative Park Studies Unit, Coll. of Forestry, Wildl. and Rang. Sciences, Univ. of Idaho, Moscow. Unpublished Report.

Mattson, D. J., R. R. Knight, and B. M. Blanchard. 1987. The effects of developments and primary roads on grizzly bear habitat use in Yellowstone National Park, Wyoming. Int. Conf. on Bear Res. and Manage. 7:259-273.

Mattson, D. J., B. M. Blanchard, and R. R. Knight. 1992. Yellowstone grizzly bear mortality, human habituation, and whitebark pine seed crops. J. Wildl. Manage. 56:432-442.

McBride, R. T., and T. K. Ruth. 1988. Mountain lion behavior in response to visitor use in the Chisos Mountains of Big Bend National Park, Texas. U.S.D.I. Nat. Park Ser. Final Report #CX-7130-002. 35pp.

McCord, C. M., and J. E. Cordoza. 1984. Bobcat and lynx. Pages 728-766 *in* J. A. Chapman and G. A. Feldhammer, eds. Wild Mammals of North America. John Hopkins University Press, Baltimore, MD.

McCullough, D. R. 1982. Behavior, bears, and humans. Wildlife Society Bulletin 10(1):27-33.

McKelvey, K. S., K. B. Aubry, and Y. K. Ortega. 1999. History and distribution of lynx in the continguous United States, Chapter 8 in USDA Forest Service Gen. Tech. Rep. RMS-GTR-30.

McLellan, B. N. 1989. Effects of resource extraction industries on behaviour and population dynamics of grizzly bears in the Flathead drainage, British Columbia and Montana. Ph. D. thesis. Univ. of British Columbia, Vancouver. 116pp.

McLellan, B. N. 1994. Density-dependent population regulation of brown bears. Pages 15-24 *in* M. Taylor, ed. Density-dependent population regulation in black, brown, and polar bears. Int. Conf. Bear Res. and Manage. Monogr. Series No. #. 43pp.

McLellan, B. N., and D. M. Shackelton. 1988. Grizzly bears and resource-extraction industries: effects of roads on behaviour, habitat use and demography. Journal of Applied Ecology 25:451-460.
McLellan, B. N., and D. M. Shackelton. 1989. Immediate reactions of grizzly bears to human activities. Wildlife Society Bulletin 17:269-274.
Mealey, S. 1975. The natural food habits of free ranging grizzly bears in Yellowstone National Park. M.S. Thesis. Montana State Univ., Bozeman. 159pp.
Mealey, S. 1979. Guidelines for management involving grizzly bears in the greater Yellowstone area. USDI National Park Service, Yellowstone National Park, Wyoming and USDA Forest Service. 136pp.
Mealey, S. 1980. The natural food habits of grizzly bears in Yellowstone National Park. 1973-74. Int. Conf. on Bear Res. and Manage. 4:281-292.
Mech, L. D. 1970. The wolf: ecology and behavior of an endangered species. Natural History Press, Doubleday, New York, New York.
Mech, L. D. 1995. The challenge and opportunity of recovering wolf populations. Conservation Biology 9:270-278.
Mech, L. D., and S. M. Goyal. 1995. Effects of canine parvovirus on gray wolves in Minnesota. Journal of Wildlife Management 59:565-570.
Mech, L. D., S. H. Fritts, G. L. Radde, and W. J. Paul. 1988. Wolf distribution and road density in Minnesota. Wildlife Society Bulletin 16:85-87.
Mech, L. D., T. J. Meier, and J. W. Burch. 1991. Denali Park wolf studies: implications for Yellowstone. Transactions of the North American Wildlife and Natural Resources Conference 56:86-90.
Miller, S. D. 1990a. Denning ecology of brown bears in southcentral Alaska and comparisons with a sympatric black bear population. Intl. Conf. Bear Res. and Manage. 8:279-287.
Miller, S. D. 1990b. Population management of bears in North America. Int. Conf. Bear Res. and Manage. 8:357-373.
Miller, S. D. 1993. Brown bears in Alaska: a statewide management overview. Alaska Dept. of Fish and Game Wildlife Technical Bulletin #11. 40pp.
Mladenoff, T. A., D. J. Sickley, R. G. Haight, and A. P. Wydeven. 1995. A regional landscape analysis and prediction of favorable gray wolf habitat in the northern Great Lakes region. Conservation Biology 9:279-294.
Mladenoff, D. J., R. G. Haight, T. A. Sickley, and A. P. Wydeven. 1997. Causes and implications of species restoration in altered ecosystems. BioScience 47:21-312.
Montana Department of Fish, Wildlife & Parks (MFWP). 1994. Management of black bears in Montana, final environmental impact statement. Helena, MT. 184pp.
Montana Fish, Wildlife, and Parks (MFWP). 1996. Final Environmental Impact Statement: management of mountain lions in Montana. Helena. 138pp.
Moore, R. E., and N. S. Martin. 1980. A recent record of swift fox *(Vulpes velox)* in Montana. J. Mamm. 61:161.

Mowat, G., K. G. Poole, and M. O'Donoghue. 1999. Ecology of lynx in Northern Canada and Alaska,Chapter 9 in USDA Forest Service Gen. Tech. Rep. RMRS-GTR-30.
Mundy, K. R. D., and D. R. Flook. 1973. Background for managing grizzly bears in the national parks of Canada. Canadian Wildlife Service Report Series no. 22. 34pp.
Murphy, K. M. 1983. Relationships between a mountain lion population and hunting pressure in western Montana. M.S. thesis. Univ Montana, Missoula. 48pp.
Murphy, K. M. 1998. The ecology of the cougar (*Puma concolor*) in the northern Yellowstone ecosystem: interactions with prey, bears, and humans. Ph.D. Dissertation. Univ. Idaho, Moscow. 147pp.
Murie, A. 1944. The wolves of Mount McKinley. U.S. National Park Service, Fauna of the National Parks Series, no. 5. Washington, D.C.
Murray, D. L. and S. Boutin. 1991. The influence of snow on lynx and coyote movements: does morphology affect behavior? Oecologia 88:463-469.
Murray, D. L., S. Boutin, M. O'Donoghue,and V. O. Nams. 1995. Hunting behavior of sympatric felid and canid in relation to vegetative cover. Animal Behavior 50: 1203-1210.
Nellis, C. H., and L. B. Keith. 1976. Population dynamics of coyotes in central Alberta. Journal of Wildlife Management. 40:389-399.
Nellis, C. H., S. P. Wetmore, and L. B. Keith. 1972. Lynx-prey interactions in central alberta. Journal of Wildlife Management 36:320-329.
Newby, F. E., and P. L. Wright. 1955. Distribution and status of the wolverine in Montana. Journal of Mammalogy 36: 248-253.
Newby, F. E., and J. J. McDougal. 1964. Range extension of the wolverine in Montana. Journal of Mammalogy 45: 485-486.

Northern Continental Divide Grizzly Bear Ecosystem Subcommittee (NCDGBES). 1980s-1990s. Annual repots, including mortality and observations. Unpublished reports.

Northern Continental Divide Grizzly Bear Ecosystem Subcommittee. 1995. Grizzly Bear Mortality and Management Activities in the NCDE, Unpublished report. 8pp.

Noss, R. F. 1995. Maintaining ecological integrity in representative reserve networks. A World Wildlife Fund Canada/World Wildlife Fund-United States Discussion Paper. Toronto, Ontario, Washington, D.C.

Noss, R. F., H. B. Quigley, M. G. Hornocker, T. Merrill, and P. C. Paquet. 1996. Conservation biology and carnivore conservation in the Rocky Mountains. Conservation Biology 10:949-963.

O'Connor, R. M. 1986. Reproduction and age distribution of female lynx in Alaska, 1961-71 preliminary results. In: Miller, S.D., D.D. Everett, eds. Cats of the world: biology, conservation and management. National Wildlife Federation, Washington, DC: 311-325.

O'Donoghue, M., S. Boutin, C. J. Krebs, and E. J. Hofer. 1997. Numerical responses of coyotes and lynx to the snowshoe hare cycle. Oikos 80:150-162.

Okarma, H., B. Jedrzejewski, W. Jedrzejewski, L. Milkowski, and Z. Krasinski. 1995. The trophic ecology of wolves and their predatory role in ungulate communities of forest ecosystems in Europe. Acta Theriologica 40:335-386.

Ozoga, J. J., and E. M. Harger. 1966. Winter activities and feeding habits of northern Michigan coyotes. Journal of Wildlife Management 30 (4): 809-818.

Paquet, P. C. 1989. Behavioural ecology of sympatric wolves (*Canis lupus*) and coyotes (*Canis latrans*) in Riding Mountain National Park, Manitoba. Dissertation, University of Alberta, Edmonton, Alberta, Canada.

Paquet, P. C., and A. Hackman. 1995. Large carnivore conservation in the Rocky Mountains: a long-term strategy for maintaining free-ranging and self-sustaining populations of carnivores. World Wildlife Fund-Canada, Toronto, Ontario, Canada.

Paquet, P. C., J. Weirczhowski, and C. Callaghan. 1996. Summary report on the effects of human activity on gray wolves in the Bow River Valley, Banff National Park, Alberta. Department of Canadian Heritage, Ottawa, Ontario, Canada.

Paragi, T. F. 1990. Reproductive biology of female fishers in southcentral Maine. University of Maine, Orono. 107 pages.

Parker, G. R., J. W. Maxwell, and L. D. Morton. 1983. The ecology of lynx (Lynx canadensis) on Cape Breton Island. Canadian Journal of Zoology 61:770-786.

Peterson, R. D. 1977. Wolf ecology and prey relationships on Isle Royale. U.S. National Park Service Fauna Series 11, Washington, D.C.

Phillips, R.L., R.D. Andrews, G.L. Storm, and R.A. Bishop. 1972. Dispersal and mortality of red foxes. Journal of Wildlife Management 36:237-248.

Poelker, K. E., and H. D. Hartwell. 1973. Black bear of Washington. Washington State Game Dep. Biol. Bull. 14. 180pp.

Poelker, K. E., and L. D. Parsons. 1977. Black bear hunting to reduce forest damage. *In:* Martinka, C. L. and K. L. McArthur (eds). 1980. Bears – Their biology and management. 4th International Conference on Black Bear Research and Management.

Poole, K.G.. 1994. Characteristics of an unharvested lynx population during a snowshoe hare decline. Journal of Wildlife Management 58:608-18.

Powell, R. A. 1979. Fishers, population models and trapping. Wildl. Soc. Bull. 7:149-154.

Powell, R. A. 1982. The fisher: Natural history, ecology, and behaviour. University of Minnesota Press, Minneapolis. 217pp.

Powell, R. A. 1987. Black bear home range overlap in North Carolina and the concept of home applied to black bears. Int. Conf. Bear Res. and Manage. 7:235-242.

Powell, R. A., and W. J. Zielinski. 1994. Fisher. Pages 38-66 *in* L. F. Ruggiero, K. B. Aubrey, S. W. Buskirk, L. J. Lyon and W. J. Zielinski (eds) The scientific basis for conserving forest carnivores: American marten, fisher, lynx and wolverine in the western United States. USDA For, Serv. Gen. Tech. Rep. RM-254.

Progulske, D. R. 1969. Observations of a penned, wild captured black-footed ferret. J. Mammal. 50:619-621. As cited in Svendsen 1990.

Pulliainen, E. 1965. Studies on the wolf (*Canis lupus*) in Finland. Annales Zoologici Fennici 2:215-259.

Pulliainen, E. 1968. Breeding biology of the wolverine *(Gulo gulo* L.) in Finland. Annales Zoologica Fennici. 5:338-344.

Pyrah, D. 1984. Social distribution and population estimates of coyotes in north-central Montana. Journal of

Wildlife Management 48:679-690.
Quinn, N. W. S., and G. Parker. 1987. Lynx. Pages 683-694 *in* M. Novak, J. A. Baker, M. E. Obbard and B. Mallock, eds. Wild furbearer management and conservation in North America. Ontario Ministry of Natural Resources, Ontairo.
Rausch, R. A., and A. M. Pearson. 1972. Notes on the wolverine in Alaska and the Yukon territory. Journal of Wildlife Management 36: 249-268.
Ream, R. R., and U. I. Mattson. 1982. Wolf status in the northern Rockies. Pages 362-381 *in* F. H. Harrington and P. C. Paquet, editors. Wolves of the world: perspectives of behavior, ecology, and conservation. Noyes, Park Ridge, New Jersey, USA.
Ream, R. R., M. W. Fairchild, D. K. Boyd, and D. H. Pletscher. 1991. Population dynamics and home range changes in a colonizing wolf population. Pages 349-366 *in* M. Boyce and R. Keiter, editors. The greater Yellowstone ecosystem: redefining America_s wilderness heritage. Yale University Press, New Haven, CT.
Reynolds, D. G., and J. J. Beecham. 1980. Home range activities and reproduction of black bears in west-central Idaho. Int. Conf. Bear Res. and Manage. 4:181-190.
Reynolds, D. G., and J. Hechtel. 1980. Big game investigation. Structure, status, reproductive biology, movements, distribution and habitat utilization of a grizzly bear population. Fed. Aid Wildl. Rest. Proj. W17-11, Job 4.1R. Job Prog. Rpt., July 1, 1978-June 30, 1979. Alaska Dept. Fish and Game, Juneau. 66pp.

Reynolds, D. G., H. V. Reynolds, and E. H. Follman. 1984. Responses of grizzly bears to seismic surveys in northern Alaska. Int. Conf. Bear Res. and Manage. 6:169-175.
Reynolds, P. E., H. V. Reynolds, and E. H. Follmann. 1986. Responses of grizzly bears to seismic surveys in northern Alaska. Int. Conf. on Bear Res. and Manage. 6:169-175.
Richardson, R. 1992. The Montana black-footed ferret recovery project. Produced by: Montana Fish, Wildlife & Parks; Bureau of Indian Affairs; Bureau of Land Management; Turner Foundation; U.S. Fish & Wildlife Service; Yellowstone Valley Audubon Society. Montana Outdoors 23(2):18-23. Helena, MT.
Rogers, L. 1976. Effects of mast and berry crop failures on survival, growth, and reproductive success of black bears. N. Amer. Wildl. Natur. Res. Conf., Trans. 41:431-438.
Rogers, L. 1977. Social relationships, movements, and population dynamics of black bears in northeastern Minnesota. Unpubl. Ph.D. Thesis. Univ. Minnesota, Minn. 194pp.
Rogers, L. L. 1983. Effects of food supply, predation, cannabilism, parasites, and other health problems on black bear populations. Pages 194-211 *in* F.L. Bunnell, D.S. Eastman, and J.M. Peek, eds. Symposium on natural regulation of wildlife populations. Forest, Wildlife, and Range Experiment Station. Univ. Idaho. Moscow, ID.
Rogers, L. L. 1987. Effects of food supply and kinship on social behavoir, movements, and population growth of black bears in northeastern Minnesota. Wildl. Monogr. 97:1-72.
Rogers, L. L., and L. D. Mech. 1981. Interactions of wolves and black bears in northeastern Minnesota. J. Mammal. 62(2):436-439.
Rolley, R. E. 1987. Bobcat. Pages 671-681 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Mallock, eds. Wild furbearer mamgement and conservation in North America. Ontario Ministry of Natural Resources, Ontario.
Ross, P. I., and M. G. Jalkotzy. 1992. Characteristics of a hunted population of cougars in southwestern Alberta. J. Wildl. Manage. 56:417-426.
Ross, P. I., G. E. Hornbeck, and B. L. Horejsi. 1988. Late denning black bears killed by grizzly bear. J. Mammal. 69(4):818-820.
Roy, K. D. 1991. Ecology of reintroduced fishers in the Cabinet Mountains of northwest Montana. University of Montana, Missoula. M.S. Thesis. 94pp.
Ruth, T. K. 1991. Mountain lion use of an area of high recreational development in Big Bend National Park, Texas. M.S. Thesis. Texas A&M Univ., College Station. 218pp.
Russell, R. H., J. W. Nolon, N. A. Woody, and G. Anderson. 1979. A study of the grizzly bear in Jasper National Park, 1975-78. Canadian Wildlife Service Report. 136pp.
Samuel, D. E., and B. B. Nelson. 1982. Foxes. Pages 475-490 *in* J.A. Chapman and G.A. Felkhamer, editors. Wild Mammals of North America, Biology, Management and Economics. John Hopkins University Press, Baltimore, USA and London, England.
Sanderson, G. C. 1987. Raccoon. Pages 487-499 *in* Novak, M., J. Baker, M. Obbard, and B. Malloch editors. Wild Furbearer Management and Conservation in North America. Ontario Ministry of Natural Resources, Ontario, Canada. 1150pp.
Sargeant, A. B., S. H. Allen, and J. O. Hastings. 1987. Spatial relations between sympatric coyotes and red foxes in North Dakota. Journal of Wildlife Management 51:285-293.

Schoen, J. W. 1990. Bear habitat management: a review and future perspective. Int. Conf. Bear Res. and Manage. 8:143-154.
Schwartz, C. C., and A. W. Franzmann. 1987. Denning ecology of three black bear populations in Alaska. Int. Conf. Bear Res. and Manage. 7:281-291.
Schwartz, C. C., and A. W. Franzmann. 1991. Interrelationship of black bears to moose in the northern coniferous forest. Wildl. Monogr. 113, 1-58.
Scott-Brown, L. M., S. Herrero, and J. Reynolds. 1987. Swift fox. Pages 433-441 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild Furbearer Management and Conservation in North America. Ashton-Potter Limited, Concord, Ontario.
Seidensticker, J. C., IV, M. G. Hornocker, W. V. Wiles, and J. P. Messick. 1973. Mountain lion social organization in the Idaho Primitive Area. Wildl. Monogr. 35:1-60.
Servheen, C. 1981. Grizzly bear ecology and management in the Mission Mountains, Montana. Ph.D. Dissertation. University of Montana, Missoula. 139pp.
Servheen, C. 1983. Grizzly bear food habits, movements, and habitat selection in the Mission Mountains, Montana. Journal of Wildlife Management 47:1026-1035.
Servheen, C. 1989. The status and conservation of the bears of the world. Presented at the 8th International Conf. on Bear Res. and Manage. Victoria, British Columbia. Canada.
Servheen, C. 1998. The grizzly bear recovery program: Current status and future considerations. Ursus 10:591-596.
Servheen, C., and R. Klaver. 1983. Grizzly bear dens and denning activity in the Mission and Rattlesnake Mountains, Montana. Int. Conf. on Bear Res. and Manage. 5:201-207.
Servheen, C., F. Hovey, B. McLellan, R. Mace, W. Wakkinen, W. Kasworm, D. Carney, T. Manley. and R. Wielgus. 1994. Reprort of the northern ecosystems researchers on grizzly bear population trends in the North and South Forks of the Flathead, and the Blackfeet Indian Reservation of the NCDE; the Cabinet-Yaak Ecosystem; and the Selkirk Ecosystem; and future data needs to improve trend estimates. Unpublished Report. U.S. Fish and Wildl. Serv., Missoula, Mont. Unpublished report. 14pp.
Shaffer, S. C. 1971. Some ecological relationships of grizzly bears and black bears of the Apgar Mountains in Glacier National Park, Montana. M. S. Thesis. Univ. Montana. Missoula. 134pp.
Simmons, C., and S. Stewart.1989. Beartooth Face black bear studies. Special big game survey and inventory, Region 5, Fed. Aid Proj. W-130-R-18. MT Fish, Wildl. and Parks, Helena.
Skiles, R. J. 1995. Black bears in Big Bend National park, the Tex-Mex connection. Proc. 5th Western Black Bear Workshop, 2/22-25/95. Provo, UT. Pp:67-72.
Slough, B. G. and G. Mowat. 1993. Yukon lynx harvest study progress report. Unpublished report in: 7th Northern Furbearer Conference, April 22-23, 1993, Whitehorse, Yukon. Yukon Department of Renewable Resources. 34 p. abstract.
Slough, B. G., and G. Mowat. 1996. Lynx population dynamics in an untrapped refugium. Journal of Wildlife Management 60:946-61.
Smith, F. H. 1929. Hunters war on predatory animals. Montana Wildlife. 2(7):9.
Snow, C. 1972. Black-footed ferret *Mustela nigripes*. Habitat Management Series For Endangered Species. Bureau of Land Management. Denver CO. Technical Report No. 2.
Soutiere, E.C. 1979. Effects of timber harvesting on marten in Maine. Journal of Wildlife Management 43: 850-860.
Sovada, M. A., C. C. Roy, J. B. Bright, and J. R. Gillis. 1998. Causes and rates of mortality of swift foxes in western Kansas. Journal of Wildlife Management. 62:1300-1306.
Spencer, W. D., R. H. Barrett and W. J. Zielinski. 1983. Marten habitat preferences in the northern Sierra Nevada. J. Wildl. Manage. 51:616-621.
Squires, J. R., and T. Laurion. 1999. Lynx home range and movements in Montana and Wyoming: preliminary results, Chapter 11 in USDA Forest Service Gen. Tech. Rep. RMRS-GTR-30.
Stebler, A. M. 1972. Conservation of the grizzly-ecological and cultrual consideration. Pages 297-303 *in* S.Herrero, ed. Bears-Their biologly and management. IUCN Publ. New Series 23.
Stenlund, M. H. 1955. A field study of the timber wolf (*Canis lupus*) on the Superior National Forest, Minnesota. Minnesota Department of Conservation Technical Bulletin Number 4:1-55.
Stephenson, R. O. 1974. Characteristics of wolf den sites. Alaska Department of Fish and Game, Juneau, Alaska, USA.
Stephenson, R. O., and L. Johnson. 1972. Wolf report. Alaska Department of Fish and Game, Juneau. Volume 10:1-52.
Stephenson, R. O., and R. T. Aghook. 1975. The Eskimo hunter's view of wolf ecology and behavior. Pages 286-291 *in* M. W. Fox, editor. The wild canids: Their systematics, behavioral ecology and evolution.

Van Nostrand Reinhold Co.
Strickland, M.A., C.W. Douglas, and M. Novak. 1982. Marten. In: J.A. Chapman, and G.A. Feldhamer, eds. Wild mammals of North America: biology, management,economics. John Hopkins University Press. Baltimore, Maryland. pages 599-612.
Strickland, M. A., M. Novak, and N. P. Hunzinger. 1982. Fisher. In: J.A. Chapman, G.A. Feldhamer, eds. Wild mammals of North America: biology, management and economics. Johns Hopkins University, Baltimore. University Press. Pp: 586-598.
Storer, T. I., and L. P. Tevis. 1955. California grizzly. University of Nebraska Press, Lincoln. 335pp.
Storm, G. L. 1965. Movements and activities of foxes as determined by radio tracking. Journal of Wildlife Management. 29:1-13.

Svendsen, G. E. 1990. Weasels. Pages 613-628 *in* J.A. Chapman and G.A. Feldhamer, eds. Wild Mammals of North America. The John Hopkins University Press, Baltimore, Maryland.
Sweanor, L. L. 1990. Mountain lion social organization in a desert environment. M.S. Thesis. Univ. Idaho, Moscow. 172pp.
Taylor, M., ed. 1994. Density-dependent population regulation in black, brown, and polar bears. Int. Conf. Bear Res. and Manage. Monogr. Series No. 3. 43pp.
Telfer, E. S., and J. P. Kelsall. 1984. Adaptation of some large North American mammals for survival in snow. Ecology 65:1828-1834.
Thiel, R. P. 1985. Relationship between road densities and wolf habitat suitability in Wisconsin. American Midland Naturalist 113:404-407.
Thiel, R. P., S. Merrill, and L. D. Mech. 1998. Tolerance by denning wolves, *Canis lupus*, to human disturbance. Canadian Field-Naturalist 112:340-342.
Thier, T. J. 1990. Population characteristics and the effects of hunting on black bears in a portion of northwestern Montana. M.S. Thesis. University of Montana. Missoula. 100pp.
Thompson, I. D., and P. W. Colgan. 1987. Numerical responses of martens to a food shortage in northcentral Idaho. Journal of Wildlife Management 51: 824-835.
Thompson, S., and K. McCurdy. 1995. Black bear management in Yosemite national Park: more a people management problem. *In:* Proc. Of the 5th Western Black Bear Workship, 2/22-25/95, Provo, UT. J. Auger and H. Black Eds. Pp:105-115.
Thurber, J. M., R. O. Peterson, T. D. Drummer, and S. A. Thomasma. 1994. Gray wolf response to refuge Boundaries and roads in Alaska. Wildlife Society Bulletin 22:61-68.
Tietje, W. D., and R. L. Ruff. 1980. Denning behavior of black bears in boreal forest of Alberta. J. Wildl. Manage. 44(4):858-870.
Torres, S. G., T. M. Mansfield, J. E. Foley, T. Lupo, and A. Brinkhaus. 1996. Mountain lion and human activity in California: testing speculations. Wildl. Soc. Bull. 24:451-460.
Tyers, D., and D. Reinhart. 1999. Grizzly bears. *In:* Olliff, S. T., K. Legg, and B. Kaeding, editors. The effects of winter recreation of wildlife: a literature review and assessment, draft report. A report from the Greater Yellowstone Coordinating Committee Wildlife Working Group.
Unsworth, J. W., J. J. Beecham, and L. R. Irby. 1989. Female black bear habitat use in west-central Idaho. J. Wildl. Manage. 53(3):668-673.
U.S.D.I. Bureau of Land Management, U.S.D.A Forest Service, U.S.D.I. National Park Service, U.S.D.I. Fish and Wildlife Service. 1999. Draft Canada Lynx Conservation Assessment and Strategy. 111pp.
U. S. Fish, and Wildlife Service (USFWS). 1982. Grizzly Bear Recovery Plan. U.S. Fish and Wildl. Serv., Denver, Colo. 195pp.
U. S. Fish and Wildlife Service. 1987. Northern Rocky Mountain Wolf Recovery Plan. Denver, Colorado, USA.
U. S. Fish, and Wildlife Service. 1993. Grizzly bear recovery plan. Missoula, Montana. 181pp.
Van Dyke, F. G., R. H. Brocke, B. B. Ackerman, T. P. Hemker, and F. G. Lindzey. 1986. Reactions of mountain lions to logging and human activity. J. Wildl. Manage. 50:95-102.
Voigt, D. R. 1987. Red fox. Pages 379-392 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild Furbearer Management and Conservation in North America. Ashton-Potter Limited, Concord, Ontario.
Voigt, D. R., and W. E. Berg. 1987. Coyote. Pages 345-357 *in* M. Novak, J.A. Baker, M.E. Obbard, and B. Malloch, editors. Wild Furbearer Management and Conservation in North America. Ashton-Potter Limited, Concord, Ontario.
Wakefield, G. C. 1972. A summary of the black bear population characteristics in Pennsylvania. Int. Conf. Bear Res. and Manage. 3:43-52.

Waller, J. S. 1992. Grizzly bear use of habitats modified by timber management. M.S. thesis. Montana State University, Bozeman. 64pp.
Waller, J. S., and R. D. Mace. 1997. Grizzly bear habitat selection in the Swan Mountains, Montana. Journal of Wildlife Management 61(4):1032-1039.
Ward, R.M.P. and C.J. Krebs. 1985. Behavioural responses of lynx to declining snowshoe hare abundance. Canadian Journal of Zoology 63: 2817-2824.
Watts, P. D., and C. Jonkel. 1989. Energetic cost of winter dormancy in grizzly bears. J. Wildl. Manage. 54(4):654-656.
Weaver, J. 1993. Lynx, wolverine, and fisher in the western United States: Research assessment and agenda. USDA Forest Service Intermountain Research Station Contract No. 43-0353-2-0598. Missoula, Montana.
Weaver, J. L. 1994. Ecology of wolf predation amidst high ungulate diversity in Jasper National Park, Alberta. Dissertation, University of Montana, Missoula.
Weaver, J. L., P. C. Paquet, and L. F Ruggiero. 1996. Ecology of large carnivores in the Rocky Mountains: a resilience perspective on conservation imperatives. Conservation Biology 10:964-976.
Weckwerth, R. P., and P. L. Wright. 1966. Results of transplanting fishers in Montana. Journal of Wildlife Management 32: 977-980.
Whitaker, J. O. 1995. National Audubon Society Field Guide to North American Mammals. Alfred A. Knopf, Inc. NY, NY.
Whitman, J. S., W. B. Ballard and C. L. Gardner. 1986. Home range and habitat use by wolverines in southcentral Alaska. J. Wildl. Manage. 50:460-463.
Wielgus, R. B. 1986. Habitat ecology of the grizzly bear in the southern Rocky Mountains of Canada. M.S. Thesis, University of Idaho, Moscow. 136pp.
Williams, J. S. 1992. Ecology of mountain lions in the Sun River area of northern Montana. M.S. Thesis. Montana State Univ., Bozeman. 109pp.
Windberg, L. A., and F. F. Knowlton. 1988. Management implications of coyote spacing patterns in southern Texas. Journal of Wildlife Management 52:632-640.
Windberg, L. A., J. L. Anderson, and R. M. Engeman. 1985. Survival of coyotes in southern Texas. Journal of Wildlife Management 49:301-307.
Yellowstone Grizzly Bear Ecosystem Subcommittee. 1980s-1990s. Annual Reports, including mortality and observations. Unpublished Reports.
Yodzis, P., and G. B. Kolenosky. 1986. A population dynamics model of black bears in east-central Ontario. J. Wildl. Manage. 50(4):602-612.
Young, S. P. 1946. History, life habits, economic status, and control, Part 1. Pages 1-173 *in* S.P. Young and E.A. Goldman, eds. The puma, mysterious American cat. The Am. Wildl. Inst., Wash., D.C. 358pp.
Young, D. D., and J. J. Beecham. 1986. Black bear habitat use at Priest Lake, Idaho. Int. Conf. Bear Res. and Manage. 6:7-80
Young, B. F., and R. L. Ruff. 1982. Population dynamics and movements of black bears in east central Alberta. J. Wildl. Manage. 46(4):845-860.
Zager, P. E. 1980. The influence of logging and wildfire on grizzly bear habitat in northwestern Montana. PhD. Thesis. Univ. Mont., Missoula, Montana. 130pp.
Zager, P. E., C. J. Jonkel, and J. Habeck. 1983. Logging and wildfire influence on grizzly bear habitat in Northwestern Montana. Int.Conf.Bear Res. and Manage. 5:124-132.
Zimmerman, A. L. 1998. Reestablishment of swift fox in north central Montana. M.S. Thesis. Montana State University, Bozeman.
Zumbaugh, D. M., J. R. Choate, and L. B. Fox. 1985. Winter food habits of swift fox on the central high plains. Prairie Naturalist 17(1):41-47.

CHAPTER 8

DOMESTIC DOGS IN WILDLIFE HABITATS

EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE

A Review for Montana

www.montanatws.org

MONTANA CHAPTER OF THE WILDLIFE SOCIETY

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ABSTRACT

It is difficult to segregate human demographic trends from trends in rural development and outdoor recreational participation in settings like the West where they appear to be interrelated. One extension of human recreation in wildlife habitats is the effect of disturbance, harassment, displacement, or direct mortality of wildlife attributable to domestic dogs that accompany recreationists. At some level, domestic dogs still maintain instincts to hunt and/or chase. Given the appropriate stimulus, those instincts can be triggered in many different settings. Even if the chase instinct is not triggered, dog presence in and of itself has been shown to disrupt many wildlife species. Authors of many wildlife disturbance studies concluded that dogs with people, dogs on-leash, or loose dogs provoked the most pronounced disturbance reactions from their study animals. During winter, concerns are primarily related to human activity on ungulate winter ranges. Dogs extend the zone of human influence when off-leash. Many ungulate species demonstrated more pronounced reactions to unanticipated disturbances, as a dog off-leash would be until within very close range. In addition, dogs can force movement by ungulates (avoidance or evasion during pursuit), which is in direct conflict with overwinter survival strategies which promote energy conservation. During summer, concerns are primarily related to the birth and rearing of young for all wildlife species. Dogs are noted predators for various wildlife species in all seasons. Domestic dogs can potentially introduce diseases (distemper, parvovirus, and rabies) and transport parasites into wildlife habitats. While dog impacts to wildlife likely occur at the individual scale, the results may still have important implications for wildlife populations. For most wildlife species, if a "red flag" is raised by pedestrian-based recreational disturbance, there could also be problems associated with the presence of domestic dogs. Managers may consider the following when evaluating recreational impacts of dogs in wildlife habitats: species biology, reproductive potential, abundance, density, distribution, degree of habitat specificity or reliance on certain habitat components, and predisposition and sensitivity to disturbance by other agents. This information is intended to increase awareness among natural resource professionals and the public about the potential implications of uncontrolled domestic dogs in wildlife habitats and to encourage responsible outdoor recreation ethics.

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INTRODUCTION

One extension of human recreation in wildlife habitats is the effect of harassment, displacement, or direct mortality of wildlife attributable to uncontrolled domestic pets. Many recreationists take their dogs along while hiking, biking, skiing, or snowshoeing. Although firewood cutting is not typically thought of as recreational in nature, this activity also puts people into wildlife habitats. Some firewood cutters bring their dogs and allow them to run. Their reasons for doing so include advance warnings of bears or lions, exercise for the dog, and companionship. These dogs also have the potential to harass wildlife. Similarly, some antler collectors intentionally allow their dogs to run while searching ungulate winter range, in the belief that the search will be more thorough, wide-ranging, and efficient because of the dog's sensitive nose and cruising behavior. There is emerging interest in sled-dog recreation and competition in Rocky Mountain states. This activity also introduces domestic dogs into wildlife habitats.

The primary objective of this chapter is to increase the awareness among natural resource professionals and the public about the potential implications of uncontrolled domestic dogs in wildlife habitats and to summarize information, where available, about documented impacts. Secondarily, the objective is to encourage resource managers to proactively consider the issue, despite the inadequacies of current information.

Some recreationists maintain control of their dogs through leash restraint while others consider voice command a form of control. Still others make little attempt to maintain control of their dogs, allowing them to travel out of sight and/or hearing distance. Despite human efforts to domesticate dogs during the past 11-12,000 years and our contemporary attempts at rigorous voice-command training, dogs still maintain instincts to hunt and/or chase. Given the appropriate stimulus, those instincts can be triggered in many different settings. Even if the chase instinct is not triggered, dog presence in and of itself may be an agent of disturbance or stress to wildlife.

This analysis distinguishes between stray and feral dogs and pets that are uncontrolled, free-running, or unrestrained. Stray and feral dogs are those not receiving care or sustenance from humans. Uncontrolled, free-running, or unrestrained dogs do receive food and shelter from their owners and are companion animals but, on occasion, are unaccompanied or uncontrolled. This definition could be met either inside or outside the context of recreational activity. The focus of this analysis is on the circumstances in which recreationists take their dogs with them and suggest that the domestic dog is an additional agent of disturbance that extends the zone of influence for human activities. Others have suggested that outdoor enthusiasts consider the ethical aspects of their outdoor recreational pursuits, some specifically mentioning dogs (Waterman and Waterman 1977, Watters 1978, Williams 1978, Leave No Trace 1997). Fischer and Fischer (1990) devote a section to responsible wildlife viewing. They describe potential consequences of approaching animals too closely or too persistently, such as separating mothers from their young or flushing incubating birds from their nest. While the authors do not specifically mention pets, the presence of a leashed dog or a loose dog can generate the same consequences. In a chapter devoted to safe and responsible viewing, Duda (1995) suggests that wildlife watchers leave their pets at home for these very reasons.

Typically, the prevailing rationale for dog restrictions, where they do occur on national forest lands, rests on the potential disruption to the experiences or safety of other recreationists rather than concern about disturbance to wildlife. In national parks, pets are typically restricted to developed human-use facilities to limit disturbance to wildlife and for human safety. Certain U.S. Fish and Wildlife Service lands are restricted to all access during nesting seasons, opening to all uses, including pets, during the remainder of the year. While there is variation in agency response and regulation and from site to site, under certain circumstances, dog disturbance to wildlife in and of itself may justify restrictions (leash restraint or total exclusion) for recreationists in wildlife habitats.

Knight and Cole (1995) recommend that recreational activities not be considered in isolation and that when more than one recreational activity occurs simultaneously, there could be unanticipated synergistic effects. Similarly, wildlife populations could suffer from the accumulating impacts of rural development and increased interest and participation in outdoor recreation. According to Ray Rasker of the Sonoran Institute (cited in Cowan 1999), people first decide where they want to live, then either find a job, create a job, or live on non-labor (investment or retirement) income. It is no secret that increasing numbers of people choose to live in the Rocky Mountain region because of quality-of-life attributes, clean air and water, hunting, fishing, wildlife viewing, scenic views, and other outdoor recreation opportunities. Gallup polls indicate that 60% of Americans over the age of 50 dream of retiring in a small town or rural county (Thrush 1999). In fact, the human population of counties in the Upper Columbia River Basin increased 96% in the early 1990s. The greatest increases occurred in "recreation" counties where recreation and tourism constitute a large portion in the economy. These counties accounted for 24% of the population increase in the area (U.S. Department of Agriculture 1996). With increasing interest in outdoor recreation and homesite development in rural settings close to outdoor recreational amenities, it is conceivable that unrestrained dogs accompanying recreationists could become an issue of biological significance. While current problems may represent isolated cases at a localized scale, the convergence of increased recreation and rural development could be synergistic. It is difficult to segregate human demographic trends from trends in rural development and outdoor recreational participation, particularly in settings like the West where they appear to be interrelated.

Potential impacts of domestic dogs on wildlife could be broadly classified as harassment, injury, or death. Harassment is the disruption of normal maintenance activities, such as feeding, bedding, or grooming. It can take the form of disrupting, alarming, or even chasing. If dogs chase or pursue wildlife, injuries could be sustained directly or indirectly as a result of accidents that occur during the chase itself rather than direct contact with the dog. Domestic dogs can thus be directly or indirectly responsible for wildlife mortality. Potential impacts to wildlife by domestic dogs also include displacement of wildlife from public to private lands and modification of wildlife behavior (as described in the ungulate chapter). The role of dogs in wildlife diseases is poorly understood. However, dogs host endo- and ectoparasites and can contract diseases from, or transmit diseases to, wild animals.

There are few published papers on simulated disturbance trials using leashed companion animals in recreational settings. Some literature does address feral or stray dogs; other papers did not make a distinction but noted problems or issues associated with dogs. While much of the research did not specifically investigate disturbance of wildlife by dogs with recreationists, under-supervised dogs could function as an agent of disturbance, generating similar consequences as stray or feral dogs. Dogs also function as an extension of their owner. Particularly while off-leash, dogs increase the radius of human recreational influence or disturbance beyond what it would be in the absence of a dog. In addition, the predictability of disturbance is diminished when dogs are off-leash. Furthermore, canids are natural, evolutionary predators of many wildlife species, and the resemblance between domestic dogs and wild canids may elicit similar responses in those wildlife species.

Because animal responses are so variable and occur in a full spectrum ranging from the direct and obvious to the covert and physiological, documenting wildlife response to human recreation is challenging. Even within a species, findings are often mixed or inconclusive. Investigations have focused on short-term responses, while long-term responses leading to potentially more serious consequences have not been studied. Furthermore, much of the work to date has focused on effects on individual animals, while impacts to the population, which are more difficult to document, have not been addressed. Potential effects to populations either go uninvestigated, are extrapolated from individual-scale results, or are hypothesized to occur with little supporting evidence. Research into wildlife response to cause-specific disturbances, such as loose domestic dogs, is even more problematic. While potential impacts for many species (such as ungulates) likely occur at the individual scale, other species or localized geographic areas may experience more significant effects. Even at the individual scale, impacts should not be summarily dismissed as insignificant, particularly in light of the limited information available at present.

There are theoretical reasons for concern and a need for increased awareness of this issue. Individual species biology, life history requirements, species distribution, animal abundance, animal density, habitat use patterns, seasonal considerations, and spatial scale dictate these reasons. Fish and wildlife agencies have traditionally focused on coarse levels of resolution when evaluating agency actions. Wildlife managers frequently think at the "population" level. However, more narrow levels of evaluation may also be warranted in some situations – down to the "individual" level. Increasingly, the general public expresses its interests and concerns at a narrow or local level, based on personal values, experience, and preferences. Some publics place great value on the individual wild animal, regardless of its contribution to a larger population, and they clearly expect agency responsiveness to their concerns about individual animal welfare. Conversely, federal land managers have traditionally evaluated proposed agency actions on a localized or "unit" basis. Recently, greater emphasis has been placed on analyzing proposed actions across larger land areas or watersheds (Amy Hetrick Jacobs, Flathead National Forest, personal communication, 1999). Nonetheless, there is a contrast between input received from individuals who express concern about 1 trail or stand of trees and input received from organizations which focus comments at the watershed level. In the context of recreational disturbance to wildlife, both levels of analysis are warranted.

EVOLUTION OF THE ISSUE IN THE LITERATURE

In the literature, documentation about dogs harassing wildlife dates back to the early 1950s. These early references were solely related to white-tailed deer. In the eastern states, hunters and many state management agency personnel perceived game populations, particularly white-tailed deer, as limited by predation and harassment by domestic dogs (Ward 1954, Giles 1960, Cochran, 1967, Houston 1968, Morrison 1968, Colorado Division of Wildlife 1973). Predation by free-running dogs was believed responsible for the perceived slow growth rate of existing and translocated populations. Many of these articles were sensational dramatizations or anecdotal arguments, commanding agency personnel to "do something" about the problem. This tone persisted despite the lack of empirical evidence substantiating the concern. The situation in the Southeast was further inflamed by a regional tradition of using dogs to hunt deer. Progulske and Baskett (1958), investigating the mobility of marked white-tailed deer in Missouri, found that hunting hounds harassed deer year-round and that the ultimate effects of the steady harassment could not be evaluated.

It was not until the 1970s that a more systematic approach was undertaken to examine the issue. This early work was intended to evaluate dog-hunting techniques used for deer in the Southeast, where deer hunting included a tradition of running deer with scent-trailing hounds. Perry (1970) studied the movements and activities of dogs owned by rural residents and concluded that deer mortality by dogs was neither large nor significant in influencing deer population dynamics in Virginia. However, he noted that 70% of the dogs trapped or observed during his study were hounds. Gavitt (1973) experimentally chased deer with hounds and non-hounds on the Radford Army Ammunition Plant, Virginia. He found hounds to be more effective and persistent trailers while non-hounds were generally faster. According to Gavitt, dogs did not limit the deer herd's reproduction or induce permanent changes to home ranges.

Some of the most detailed literature on the behavior of free-running companion dogs is reported by Sweeney et al. (1971) and Corbett et al. (1971). Their subjects were purebred dogs selected for their hunting ability in the pursuit of white-tailed deer. Sweeney et al. (1971) stated that hunting hounds are specifically trained to run deer and vocalize regularly while trailing deer and cautioned that the behavior of other free-running dogs (mixed breeds in a hunting context or domestic pets) is likely different. It could involve stalking, trailing silently, or chasing by sight.

Sweeney et al. (1971) examined the responses of radio-marked white-tailed deer chased by hunting hounds in a southeastern coastal plain environment with streams and swamps. They reported average chase times of 33 minutes (range 3-155 minutes) and an average chase distance of 2.4 miles (range 0.2 – 13.4 miles). Deer left their home ranges in 78% of the experimental chases, generally returning within one day. The authors also stated that as deer population density increased, chase duration decreased because of the greater probability that hounds would switch to the trail of another deer. One unexpected finding was that instrumented deer responded to disturbance created by hounds chasing other uninstrumented deer and moved measurable distances away. Sweeney et al. (1971) cautioned that free-ranging dogs (non-hounds) might exhibit different chasing behaviors by stalking, trailing silently, or chasing by sight or scent. They further cautioned that their results might not apply in rugged mountainous terrain or areas with snow cover. No dog-induced mortality was documented for their study animals.

Corbett et al. (1971) conducted a similar study using hunting hounds in the mountainous terrain of western North Carolina. They recorded an average chase time of 54 minutes (range 4-165 minutes) and similar chase distances as Sweeney et al. (1971). In 70% of the cases, deer left their home ranges, resulting in longer chases than those in which the animal did not leave its home range. In about 50% of the cases in which deer left their home range, deer took longer than one day to return and, in some cases, considerably longer than that for white-tailed deer in coastal plain habitats. The authors noted that deer seemed to suffer physical injury more frequently while being chased in mountainous terrain because of the complex physiography. Dog-related mortality was documented. For one mortality incident, the deer appeared to suffer from parasitic damage to its lungs, rendering it "incapable of sustained running whereby it could have eluded dogs." Corbett et al. (1971) speculated that in mountainous habitats, deer could have been under greater physical stress, on a poorer nutritional plane, or otherwise weakened and more susceptible to dog predation. They concluded that dogs "may have a significant impact on populations."

In a survey of state and territorial departments of agriculture and wildlife/natural resources, Denny (1974) found that 86% of the wildlife agencies considered uncontrolled companion animals a problem for wildlife. Wildlife agency respondents listed damage to wildlife as the highest-ranking problem, affecting deer, small mammals, and birds (in descending order o f importance). Predictably, agricultural agencies listed damage to livestock as the greatest problem with uncontrolled companion animals. Wildlife respondents lacked data on the extent of losses or damages and the economic value of losses, whereas agricultural respondents could estimate economic losses. Mosby (1973), as cited by Denny (1974), concluded that definitive data on the influence of dogs on all forms of wildlife were all but impossible to attain. Nonetheless, Denny (1974) concluded, "It is apparent, though not well-documented, that the impact of dogs (and cats) can be detrimental to wildlife under specific circumstances, depending on the wildlife species involved, the relative populations of predatory and prey species, other mortality factors, habitat factors (quality, physiography, geographic location) and land use (the incursion of developments into wildlife habitats)."

Denny (1974) also cautioned: "In the Rocky Mountain region and similar regions of high snowfall, the concentration of big game on limited winter ranges provides an excellent opportunity for dog predation. This is becoming more prevalent in skiing and other recreational areas, as well as in mountain home development areas."

In more contemporary literature, domestic dogs are frequently cited as agents of mortality in ungulate research (Gavin et al. 1984, Sarbello and Jackson 1985, Nelson and Woolf 1987, Fuller 1990). Mortality attributed to domestic dogs has been documented in winter (adults and fawns) and in spring (prior to recovering physical condition post-winter) for all ages and neonates. These studies attributed 2-3% of annual mortality to domestic dogs. The researchers did not know whether the dogs were companion animals owned by nearby landowners or by recreationists or were stray/feral animals, as many of these studies were conducted on national wildlife refuges or similarly designated wildlife management areas used by the public. None of the authors concluded that domestic dogs were a significant or determining influence on population dynamics, but they discussed domestic dogs as predators. Some researchers distinguished between domestic dogs and other predator species and treated them separately. Others, such as Nelson and Woolf (1987), were unable to distinguish between coyote and domestic dog predation and combined the two into one category.

Sime and Schmidt (1999) reported that a free-running domestic dog (with collar) was photographed at two locations by remote camera stations approximately 1.5 miles apart on the same day. This particular dog was also photographed on 3 other occasions within a two-week period at locations up to 2.5 miles apart. This dog was likely owned by a landowner adjacent to the study area, but this is unconfirmed. The cruising radius of rural pet dogs could be up to 3 to 5 miles (D. Swanson, Animal Control Officer, Flathead County, Montana, personal communication, 1999). The behavior of domestic dogs while at large or while off-leash in a recreational setting is undocumented in the peer-reviewed literature. Anecdotal evidence suggests that dog behavior while at large or off-leash and in a recreational setting varies with training, breed, experience, stimuli encountered, and owner attitudes.

The presence of domestic dogs may introduce diseases or parasites to small mammals, and the burrows of fossorial mammals can be physically damaged as a result of domestic dogs (Stuht and Youatt 1972, Thorne et al. 1982, Durden and Wilson 1990). In addition, dogs walking across burrows caused alarm reactions (Mainini et al. 1993). In the case of birds, the presence of dogs may flush incubating birds from nests (Yalden and Yalden 1990), disrupt breeding displays (Baydack 1986), disrupt foraging activity in shorebirds (Hoopes 1993), and disturb roosting activity in ducks (Keller 1991). Many of these authors indicated that dogs with people, dogs on-leash, or loose dogs provoked the most pronounced disturbance reactions from their study animals.

As there are life history stages of various wildlife species in which disturbance by domestic dogs could cause particularly pronounced impacts, the following sections address potential effects by season. Where possible, published literature specifically related to dogs is presented to demonstrate impacts. In the absence of published literature, potential impacts from domestic dogs are speculated, as indicated.

POTENTIAL IMPACTS, WINTER – EARLY SPRING

Ungulates

For many species in northern latitudes, the winter season presents significant challenges for survival. Many species have adapted to winter conditions through development of migratory movements to lower elevations, behavior modification, and physiological adjustments, all of which enhance overwinter survival. For ungulates, the stresses imposed by deep snow, food shortages, and low ambient temperatures combine to depress body condition. The primary survival strategy used to mitigate these stresses is energy conservation. As described in the ungulate chapter, human activity on ungulate winter ranges generates a wide variety of responses, most of them negative. The most significant response is a forced movement away from the human disturbance, which is energetically disadvantageous to ungulates. Domestic dogs could promote forced activity in a manner consistent with non-motorized recreation.

Parker et al. (1984) suggested that greater flight distances occur in response to skiers or individuals on foot compared to snowmobiles and that unanticipated disturbance may have a more detrimental effect. Freddy et al. (1986) and Freddy (1986) also reported that responses by mule deer to persons afoot, when compared to snowmobiles, were longer in duration, more often involved running, and required greater energy expenditures. Loose domestic dogs may function as an unanticipated disturbance, undetected until at a range close enough to be registered by the senses of the wild ungulate. This is in distinct contrast to the sound of a snowmobile, which is detected by the animal while it is still some safe distance away. If a human was accompanied by a loose dog, forced activity could be more protracted spatially and/or temporally if the individual animal was being chased by the dog. (Readers are advised that there are limited published references in the context of loose companion animals to substantiate this suggestion.)

Sime and Schmidt (1999) documented a statistically significant increase (during a 10-year period) in dog presence on a publicly owned white-tailed deer winter range that has attracted increasing numbers of recreationists from a nearby major population center. Eighty-nine percent of free-running dogs detected by remote camera systems were companion animals, as evidenced by collars and good body condition. Photographic evidence of dogs chasing deer was also obtained. Sixty-six percent of the photographs were taken during daylight hours. It is not known whether those dogs belonged to nearby rural homeowners or were accompanying, off-leash, their recreating owners who remained undetected by the cameras. Nonetheless, the ability and success of domestic dogs in harassing, injuring, and killing white-tailed deer on this winter range has been documented (Sime 1996).

In a study of bighorn sheep, which were already partially habituated to humans, MacArthur et al. (1982) conducted human-disturbance trials in which a person approached a group of sheep from a road, from the road accompanied by a leased dog, and from a ridge away from the road. The authors recorded the strongest negative reactions in the sheep when a human with a leashed dog approached. Furthermore, the researchers did not observe a reduction in heart-rate response with repeated trials. Heart-rate response actually increased successively in the leashed-dog trial. In earlier work, MacArthur et al. (1979) found that free-ranging dogs and coyotes evoked the maximum heart-rate responses. Among all the stimuli they studied, MacArthur et al. (1982) concluded, “The presence of dogs on sheep range should be discouraged.”

Effects of disturbance on moose have been researched primarily in the context of oil and gas extraction (Rudd and Irwin 1985) and mining (Westworth et al. 1989). Results of these studies were summarized in Olliff et al. (1999). In general, Shank (1979) reported that moose appeared to be relatively tolerant to human approach, as indicated by flight distances. However, the flight behavior of moose is often misinterpreted because it is frequently more subtle than that of other ungulates. Shank (1979) noted that moose would commonly not react immediately and overtly to disturbances unless the stimulus was intense. While seemingly unaffected by the stimulus, moose would move toward cover. Not until reaching cover would the moose look directly at the source of the disturbance, then run. Physiological responses such as increased respiratory or heart rates were probably taking place all along, though not obvious to observers. While most studies of moose disturbance in winter demonstrate changes in movements and habitat use, no studies have documented demographic effects.

In western Wyoming, Rudd and Irwin (1985) documented disturbance response by moose to trucks associated with oil and gas extraction, snowmobiles, and to people on snowshoes or skis. Although dogs were not specifically included in the trials, results are suggestive of minimum threshold values for disturbance; more pronounced reactions or shorter flight distances could be expected if domestic dogs accompanied the foot-based recreationists. People on skis or snowshoes caused more disturbances to moose than snowmobiles. Non-motorized winter recreational activities caused 89% of monitored moose to be displaced, while snowmobiles caused 50% displacement, and trucks caused 21% displacement. Furthermore, 100% of observed moose demonstrated disturbance behaviors when disturbed by skiers and snowshoers, moving an average of 80 yards away. In contrast, 94% of moose moved 50 yards when disturbed by snowmobiles. As for other ungulate species, moose also seem more sensitive to unanticipated disturbances. Rudd and Irwin (1985) recommended that winter recreational use and mining activity is restricted near preferred moose winter range.

While moose show some propensity for habituation to humans, flight and stress responses in moose are most likely when disturbances are unpredictable, intense in sensory perception, and close in proximity (Olliff et al. 1999). Negative impacts of responding to disturbances include increased energy expenditures before, during, and after flight and reduced foraging time. The very presence of domestic dogs could theoretically intensify moose response to winter recreationists. Dog behavior is unpredictable and dogs could encounter moose at close range unexpectedly. From an evolutionary perspective, wild canids are natural predators of moose. Unless habituated, moose may perceive domestic dogs as similar to wild wolves and respond accordingly with a standing defense rather than a flight response. It was recommended in Olliff et al. (1999) that public education includes the potential impact of dogs on moose.

Gavitt (1973) summarized research on domestic animals that suggested that elevated body temperatures at conception and during early gestation could influence embryonic viability (Hulet et al. 1956, Vincent and Ulberg 1965, Ulberg and Burfening 1967). Furthermore, Shelton (1964) (as cited in Gavitt 1973) reported low birth weights and increased lamb mortality resulting from the effects of high temperatures during gestation, although in this study heat stress was related to ambient temperatures rather than body core temperature. Hulet et al. (1956) reported that any factor that tended to increase body temperature, including exercise, tended to reduce fertility in sheep. Whether elevated body temperatures in wild ungulates actually decrease fertility or induce embryonic mortality is unknown. Many ungulate species enter the winter season having just completed the breeding season, and pregnant females would be in early gestation.

In a personal communication (cited in Gavitt 1973), Downing stated that temperatures as high as 109°F were measured for 6 deer killed while being run by dogs. Normal rectal temperature for deer is 101°F (Clark and Jessup 1992). These authors caution that a rectal temperature of 106°F, in a capture situation, is of concern and attempts should be made to cool the animal. Body temperatures exceeding 108°F constitute an emergency situation, and treatment should begin immediately. If temperatures exceed 110°F, mortality is very likely. Normal rectal temperature for elk is similar to deer whereas normal temperature for bighorn sheep is 98-99°F. In general, body temperatures elevated by exercise and stress-induced physiological complications (such as elevated respiratory rates) can be triggered by human disturbance, and may be exacerbated by the presence of domestic dogs.

Bighorn sheep vulnerability to human disturbance and the more pronounced negative impacts to them if dogs accompany humans have been documented. The documentation to date mostly describes changes in physiological parameters, behavior, or displacement. However, because the breeding season occurs in early winter, there could also be population demographic effects if sheep are disturbed during the breeding season, which corresponds with the onset of winter cross- or backcountry skiing.

The negative impacts of disturbance and harassment by humans and their companion animals would logically become more pronounced as winter conditions become more severe. Readers are referred to the ungulate chapter for additional discussion of this topic. At present, only the work of Corbett et al. (1971) in western North Carolina describes outcomes of experimental chases in winter season and "extremely hilly terrain." Most of their study area was below 4,400 feet and was comprised of northern hardwood forest (oak and oak-pine) and spruce-fir forest types interspersed with food plots. Outcomes in harsh Rocky Mountain winter environments could be more severe.

The ungulate chapter emphasizes the importance of early spring in assuring recovery from winter weight loss. The authors caution that despite warming temperatures and reduced snow depths, until green forage is available in sufficient quantities and animals begin reversing the winter-induced decline in physical condition, ungulates remain susceptible to the negative effects of disturbance. Human presence in this context, particularly by antler collectors who employ their dogs in the search, can cause ungulates to succumb to stresses that would be considered minor at other times of the year.

Other Species

In winter, wolves localize their foraging to ungulate winter ranges. Ungulates seem to be most vulnerable to winter human disturbance from skiers and snowshoers. Potentially, there would be more disturbance if pets accompany recreationists. Therefore, wolves could be indirectly influenced by redistribution of their prey base by humans and by humans accompanied by dogs. Packed snow trails created by snowmobiles, if routed to or through ungulate wintering areas, may in effect provide access to wintering ungulates by wolves or dogs (companion dogs with recreationists and/or residential dogs), thereby increasing disturbance and predation. In addition, there is the potential for direct encounters between wolves and domestic dogs. Although wolves demonstrate a wide range of response to human disturbance during all seasons, less tolerance is demonstrated while denning, which begins in early spring. Readers are referred to the wolf section for additional discussion of wolf – domestic dog issues.

Low population densities characterize mid-sized forest carnivores (e.g., marten, fisher, lynx, wolverine), low reproductive rates, large home ranges, secretive behavior, and, generally, low tolerance of human presence and activity. Although poorly understood, forest carnivores demonstrate a high degree of habitat specificity during some life stages. Therefore, these animals could be vulnerable to disturbance by humans in various spatial and temporal matrices, particularly if pets accompany humans. Companion animals may amplify negative responses of forest carnivores to human disturbance, although this topic has not been addressed in the literature. Readers are referred to the forest carnivore section for additional discussion. As an additional problem, domestic dogs can be vectors for transmission of such diseases as distemper, which also affect wild carnivore species.

POTENTIAL IMPACTS, LATE SPRING/SUMMER

Companion dogs extend the radius of human recreational influence in the landscape. During summer, concerns are primarily related to the birth and rearing of young for all wildlife species. While dog impacts likely occur at the individual scale because of lower summer densities of wildlife populations relative to winter, the results may still have important implications for the wildlife populations. Potential impacts on reproductive performance at the individual and population level vary by species, abundance, habitat use, the specificity of habitat requirements during young-rearing phases, and the behavior and experience of the individual animal. Colonial nesters, for example, are sensitive to disturbance, and if disturbances are frequent enough or are of sufficient magnitude, an entire reproductive season could be forfeited by the colony.

Late spring and summer recreational activities that bring humans and their dogs into wildlife habitats include hiking, backpacking, bicycle riding, boating, horseback riding, camping, picnicking, wildlife viewing, outdoor photography, fishing, and firewood cutting. Because recreationists are no longer constrained by snow, impacts could be dispersed but broadly applied throughout the landscape, such as a trail network traversing a wilderness area or national park. Disturbance can also occur unexpectedly at established human recreation focal areas such as campgrounds. In one such instance, two small domestic dogs working together like wolves harassed a moose calf. The dogs made physical contact, though the calf apparently survived. This incident took place in mid-June 1997 at a campground located along a major highway. The dogs' owners stated that they were unaware of the incident (P. Finnegan, Law Enforcement Officer, Lewis and Clark National Forest, personal communication, 1999).

In addition, particular summer habitats and associated wildlife species could be more vulnerable to disturbance by recreationists and their pets. Sensitive alpine environments are readily accessed and sought out by enthusiasts. Because summer growing seasons are so short, physical disturbance by dogs (through digging or bed-making) could damage vegetation and soils, with resulting influences on vegetation, soils, and wildlife such as small mammal populations. Some wildlife species, such as mountain goats or bighorn sheep, are limited in their habitat choices by the need for security cover (i.e., steep topography). However, these preferred summer habitat features are also sought out by recreationists for the "view," resulting in disturbance or displacement. Domestic dogs could especially impact alpine wildlife species because alpine environments are isolated and have a patchy distribution in the landscape.

Not traditionally considered a dispersal agent for noxious weed seeds, domestic dogs do pick up and transport seeds in their hair and paws. While the scale of noxious weed seed transport by dogs is small compared to that of motorized vehicles, dogs can travel and deposit seeds in locations far removed from roads and trail systems. Because these areas are not traveled as frequently as roads, emerging weed plants may go undetected and not be treated in a timely manner. Readers are referred to the vegetation and ungulate chapters for a more thorough discussion of noxious weeds.

Pet food is known to attract many species of wildlife, including bears, squirrels, jays, and raccoons. The issue of pet food storage is important at campgrounds as well as in remote backcountry settings. Wild animals that obtain improperly stored foods may become habituated, with predictable outcomes as described in the various species chapters.

There are limited published references addressing human recreational disturbance to wildlife in summer, particularly when human recreation is coupled with companion dogs. However, as with winter-based disturbances, potential impacts can be anticipated by managers based on species biology, seasonal activities and requirements, and reasonable assumptions. Unanticipated disturbances involving foot-based recreationists with their dogs may elicit the greatest stress reactions. Consequences would then be commensurate with the intensity of disturbances, their frequency, and their timing. The following sections summarize published literature.

Ungulates

The ungulate chapter presents a thorough review of general seasonal biology and published literature related to human disturbance and its potential impacts during summer. The vulnerability of ungulate species to direct and indirect injury or mortality from domestic dogs has been previously discussed. Of particular note, however, is the vulnerability of neonatal ungulates (up to e weeks of age) to harassment, injury, or mortality by dogs (Dood 1978, Nelson and Woolf 1987). This window of vulnerability corresponds to the period that newborns hide, attain mobility, then increase activity but remain too slow to evade chasing canids. Disturbance by recreationists and their dogs may render ungulates more vulnerable to naturally occurring wild predators such as coyotes, which track human scent. It may also disrupt visitation by lactating mothers.

Ingold et al. (1993) reported responses of chamois in the Swiss Alps to the presence of hikers. Chamois are an alpine-dwelling, ecological relative of North American mountain goats. With moderate trail-hiking disturbance, male chamois altered their use of a preferred grazing area, avoiding the area altogether when hikers were present.

In Olliff et al. (1999), it was noted that moose have difficulty dissipating heat because of their large body size and heat stress could reduce overall activity during warm periods. Ambient air temperatures above 57°F can cause moose to seek out cooler areas. Renecker and Hudson (1986) reported that moose increased their respiration rate when ambient temperature exceeded 57°F, stating that moose are easily heat stressed. Similarly, elk reduced their activity after temperatures exceeded 75°F (Lieb 1981). Metabolic rates of caribou were lowest in February and highest in May (Chappel and Hudson 1978). Disturbance and/or forced movement during summer may be more problematic than during winter for many ungulate species from a physiological perspective because of a greater sensitivity to heat stress. As physical activity can increase body temperatures, ungulates may suffer physiological complications from being harassed by a dog in summer.

Other Species

Bird species are variously affected by human disturbance, as described in the bird chapter. In many cases, pedestrians generated the most negative responses (Hanson and Grant 1991), and the presence of dogs may intensify bird responses to pedestrians. Dogs themselves can disrupt habitat use, cause similar displacement responses, and injure or kill birds. Some published literature is summarized below to demonstrate the spectrum of potential impacts. Readers are also referred to the bird chapter for additional information.

Burger (1986) described the effects of human activity on shorebirds in two coastal bays of New Jersey between late April and late October. People walking accounted for 43% and 50% of bird disturbances in the two bays, respectively. Other disturbances noted were fisherman, airplanes, dogs, clam diggers, off-road vehicles, boats, children, and joggers, in descending order of occurrence frequency. Results indicated that more shorebirds flushed as the total number of disturbances and the number of children, joggers, people walking, dogs, aircraft, and boats increased. The number of human disturbances was high between May and August, coinciding with peak numbers of shorebirds. Fewer birds remained on the beaches during disturbances from late May to early August.

In a study of piping plover ecology and responses to human disturbance, Hoopes (1993) documented that adult plovers and their chicks spent 8% and 15%, respectively, of their time responding to human-related disturbances. Human-related disturbances to plovers were quantified as follows: pedestrians 86%, pets 7%, off-road vehicles 5%, and kites 2%. Pedestrians within 50 meters of study birds caused them to stop feeding 31% of the time, while pets within 50 meters caused birds to stop feeding 52% of the time. Plovers responded to pedestrians and pets at 23 meters and 46 meters, respectively. Although Hoopes documented a 33% mortality rate for chicks, neither the percentage of chicks fledged nor the mean number of chicks fledged per pair was significantly correlated with disturbance rates. The cause of death for 10 chicks was attributed to predation by a house cat (n=3), predation by a herring gull attracted by a fisherman (n=3), human disturbance or handling (n=3), and being run over by an off-road vehicle (n=1). Hoopes (1993) recommended management actions that restrict dogs and off-road vehicles, provide refuge areas for chicks, and apply symbolic fencing to reduce the impacts of disturbance on chick survival.

Yalden and Yalden (1990) similarly studied nesting and rearing ecology of golden plovers in relation to human disturbance. Golden plovers were sensitive to the presence of people within 200 meters and flushed more often during the pre-incubation period. Once incubating, golden plovers remained on the nest 96% of the time when disturbed but would have incubated 98% of the time in the absence of disturbance. During this phase, plovers flushed more readily in response to dogs than to people and took longer to resume incubation if people or dogs were still present. Once hatched, chicks hid in response to alarm calls from parents, neither able to feed nor be brooded. Adult plovers spent about 11% of the observation day responding to people, flying more often and increasing energy expenditures by 15%. Some plover pairs opted for intraspecific interactions rather than remaining in areas vulnerable to human disturbances. Pairs did this by moving chicks to quieter areas and encountering resistance from occupants of the territories they had invaded.

While studying the effects of human disturbance on eider ducklings, Keller (1991) found that ducklings were disturbed while roosting on the shoreline and while feeding in water. The shore-based activities (fishing, people walking, dogs) caused more disturbance than water-based activities (windsurfing, boating). Disturbance affected the activity of young eiders for up to 35 minutes. Keller (1991) reported that small ducklings experienced a numerical increase in predator encounters during the first 5 minutes post-disturbance.

Males of some gallenacious bird species establish territories on leks and are visited by females for courtship and mating purposes during the spring breeding season. Females visit leks during a narrow window of time, and most breeding takes place within a 1-2 week period. Species demonstrating this pattern include sage grouse, sharp-tailed grouse, and prairie chickens. Baydack (1986) experimentally disturbed sharp-tailed grouse using parked vehicles, snow fencing, propane “bangers,” scarecrows, radio sounds, human presence, and leashed dogs. Male sharptails tolerated all experimental disturbances and continued to display, except when disturbed by visible human presence and leashed dogs. With human presence, males flushed from the lek but generally remained within 400 meters of it and returned within 5 minutes following cessation of the disturbance. In contrast, female sharp-tailed grouse were much more sensitive, being displaced from leks by all tested disturbances. Unfortunately, females were not monitored, so whether they returned upon cessation of the disturbance is unknown. Patterson (1952) reported that male sage grouse would flush as a human entered a blind but would return 20-30 minutes later so long as the initial disturbance took place prior to twilight. If disturbed during morning dawn or later, birds did not return until the next display period. Because of high lek fidelity and the persistence of individual leks through time, disturbance of birds during this sensitive life history phase has important implications for population productivity, long-term population viability, and the perpetuation of viable leks into the future. Because females attend leks for such a brief period of time, disturbance could potentially influence nesting chronology and fecundity for a local bird population.

In a study of tourism in the Swiss Alps, Ingold et al. (1993) conducted disturbance trials on ptarmigan. The authors demonstrated that nesting ptarmigan a depressed slow heart rate when a hiker approaches the nest. Hens exhibit similar reactions during the breeding season in the context of predator avoidance.

Other species may be affected by summer recreational activities, as well. In the same study, marmots were experimentally disturbed by hikers on-trail, off-trail, and those accompanied by dogs. Marmots demonstrated a greater reduction in their flight distances than expected in response to hikers (Ingold et al. 1993), however, responses were more pronounced for hikers off-trail and hikers with dogs. Mainini et al. (1993) reported similar findings in their study of marmots in the Swiss Alps. Marmots reacted differently to various tourist-hiking regimes. The smallest disturbance reaction was noted when hikers restricted themselves to trails. Increasing reactions were noted with cross-country hiking and subsequent crossing of main burrows. The most severe reactions were documented in trials with dogs on a leash. Marmots gauged their responses by the predictability and nature of the potential threat (Mainini et al. 1993).

DISEASES AND PARASITES

Domestic dogs can potentially introduce various diseases and transport parasites into wildlife habitats. Furthermore, dogs can transmit diseases and parasites to wild animals directly and *vice versa*. In some circumstances, effects of diseases or parasites on wildlife are manifested in isolated areas with some limited illness or individual mortality. However, in other cases, such as with canine distemper, potential impacts are much more significant and are manifested in broader geographic areas and with real demographic effects. Generally, I assume that companion dogs are in good health, well cared for, and receive regular veterinary examinations; however, this is not always the case. While dogs can be vaccinated against many of the diseases listed below, adherence to recommended vaccination schedules is necessary for even adult dogs to maintain immunity. Specific concerns for wolves are noted in that chapter. Information presented in this section is taken from Thorne et al. (1982), unless otherwise cited.

Canine distemper occurs throughout the world, but Thorne et al. (1982) consider it “common” in the intermountain region. All canids as well as other carnivores and mustelids are susceptible to infection. Transmission occurs via direct contact between susceptible individuals and animals shedding the virus or by aerosol (inhalation of airborne droplets released by infected animals when coughing or sneezing). Mortality rates range from 20-100%, depending on the species. Canine distemper could be a significant limiting factor for carnivore populations and is generally fatal in ferrets. Contact between domestic dogs and wild carnivores may occur in the context of outdoor recreation, and the disease could be transmitted among species, though generally not to humans.

Rabies is an acute viral disease that can infect all warm-blooded animals, including humans, and it is generally fatal. It is transmitted by the bite of an infected animal, ingestion of infected tissues, inhalation of aerosols, and transplacental passage. Rabies was first reported in dogs in Florida in the late 1700s and was documented in western states beginning in the early 1800s. Though often thought of in the context of bats, skunks, and raccoons, rabies has also been documented in fox, other canids, moose, and deer. Outbreaks can result in extensive die-offs in wild populations throughout broad geographic areas, with many species affected. Of particular significance for rabies is the incubation period between exposure and clinical symptoms, which varies from 10 days to several months (Adrian 1981), with 2 to 3 weeks being more common. A dog owner may be unaware that his pet was exposed to rabies until clinical symptoms appear. Domestic dogs could introduce rabies into wild populations after exposure but prior to clinical illness. Furthermore, although infection rates in wild populations are generally very low, domestic dogs could contract rabies from an encounter with a wild animal and, in turn, expose other wildlife, pets, and humans to the disease.

Parvovirus was first documented in the United States in the early 1970s. It is now considered ubiquitous in the environment, though it currently exists in variant forms other than the original strain. All canines are susceptible, including domestic dogs, wolves, foxes, and coyotes. Transmission occurs through contact with contaminated feces, and animals are infectious for up to 2 weeks post-exposure. Because all adult domestic dogs can be considered “exposed” at least to some extent and have produced antibodies in response, canine parvovirus generally afflicts only puppies and adolescent dogs in the domestic population. However, this viral disease is life-threatening for all canines and if untreated results in death. Parvovirus was implicated in wolf pup mortality for wolves inhabiting the Glacier National Park area (Boyd et al. 1993).

Plague is an acute, infectious disease associated with rodents, rabbits, and associated carnivore and scavenger species. It is also transmittable to humans. Thorne et al. (1982) suggested that the reasons for increased incidence of human plague the 1970s were three-fold: a substantial increase in human population in Western plague areas, heavier use of recreation areas, and maintenance of “natural” landscapes around human structures. Plague is transmitted by the bite of infected fleas, by direct contact with infected animals, ingestion of infected carcasses or under-cooked meat, or by aerosol. Mammals demonstrate individual and interspecific patterns of susceptibility and resistance to plague. As such, implications for wild animal populations vary by species, although ground squirrels, ferrets, bobcats, hares, and prairie dogs can be heavily impacted by plague outbreaks in localized settings. Canids appear to be more resistant, showing little if any ill effects of plague infection directly although canids may be indirectly affected by infection of a prey population and a subsequent decline in numbers. Felids, however, can become very ill with frequent progression to mortality. Domestic dogs can pick up infected fleas from small mammals, transporting the fleas to new, unexposed locations.

Giardia, a genus of protozoa causing intestinal disorders, is found worldwide, but the Rocky Mountain region is a "hot spot," primarily because of human association with outdoor recreation. Giardiasis can be directly transmitted from one animal to another when cysts are ingested with contaminated feed or water. Flies are also thought to transport cysts from fecal stools to food and water sources used by other animals and humans. It is doubtful that giardiasis is influential in wildlife population dynamics because even acute cases usually subside to a chronic nonclinical state, but it is important for human-health reasons. Thorne et al. (1982) considered infected pets as a source of infection for humans and as a vector introducing contaminated feces into an area.

Dog feces have also been implicated in the transmission of muscle cysts (*Sarcocystis* spp.), which can infect a variety of ungulate species including elk, mule deer, and white-tailed deer. While the carnivorous hosts are seemingly unaffected, ungulates may be adversely affected to the point of illness or death.
Leptospirosis is a bacterial disease that affects the kidneys and urinary tract. Many species of wildlife are affected, including small mammals, muskrats, white-tailed deer, antelope, moose, bobcats, foxes, beaver, raccoons, and skunks. This disease does not appear to strongly influence population trends, but it can result in mortality in localized areas. In 1977, the Center for Disease Control considered domestic pets as a possible source for human infections.

Finally, Thorne et al. (1982) describe various other ecto- and endoparasites that can be transported by domestic dogs. They include ticks, keds, tapeworms, and fleas.

CONCLUSIONS

Published data specific to wildlife disturbances attributable to companion dogs are lacking. Furthermore, because of concerns about animal welfare and treatment during scientific investigations, evaluation of direct dog harassment of various wildlife species may not be feasible. Experimental protocols may not conform to ethical standards set by oversight committees. Therefore, managers are urged to consider the following when evaluating recreational impacts: species biology, reproductive potential, abundance, density, distribution, degree of habitat specificity or reliance on certain habitat components, and predisposition and sensitivity to disturbance by other agents. For most species, if a "red flag" is raised by pedestrian-based recreational disturbance, it is also likely there could be problems associated with the presence of domestic dogs. Even though strong evidence may be lacking, managers should not dismiss the possibility.

There are many educational opportunities to inform pet owners of the potential impacts to wildlife from dogs and to encourage responsible outdoor recreation ethics. In conclusion, maintaining control of pets while in wildlife habitats lessens the potential of disturbance or injury to wildlife, wildlife mortality, and injuries to pets and their owners.

GUIDELINES/RECOMMENDATIONS

Guidelines are based on information presented in the species chapters. They were developed considering species life history, seasonal biology, interpretation and synthesis of published literature, personal experience with my own and others'dogs, professional judgement, and discussions with peers. I propose the following guidelines for minimizing dog – wildlife interactions.

1. Increase agency and public awareness through interpretive/educational materials about responsible pet ownership in the context of wildlife disturbance during any and all outdoor recreational pursuits.

2. Consider whether or not a site is sensitive to wildlife disturbance by dogs when evaluating recreational facility development, facility upgrade or expansion (e.g., expanded parking areas, restrooms, or when promoting recreation at specific sites). Also, evaluate landscape level effects on traditional migration routes or the relative scarcity of important habitats.

3. Prohibit dogs where human recreation takes place on publicly owned ungulate winter ranges. If exclusion is not feasible, at a minimum, dogs should be leashed. Voice command is not adequate.

4. Prohibit dogsledding on ungulate winter ranges. If dogsledding cannot be excluded, confine travel to designated routes.

5. Restrict antler collection and other recreational activities in which dogs are present until May 15th on ungulate winter ranges, which allows ungulates to naturally disperse from their winter ranges during and after spring green-up.

6. Keep dogs leashed while in sensitive wildlife habitats, such as waterfowl nesting areas, nesting colonies, alpine habitats, or where young are still vulnerable.

7. Secure pet foods at all times; treat it the same as human foods.

8. Address the potential role of domestic dogs in disease transmission to wildlife and *vice versa* in educational materials; information should include endo- and ectoparasites.

INFORMATION NEEDS

The behavior of domestic dogs while off-leash in recreational settings with their owners is undocumented in the peer-reviewed literature for any season. Anecdotal evidence suggests that dog behavior while off-leash and in a recreational setting varies with training, breed, experience, stimuli encountered, and owner attitudes. Documentation of dog behavior would aid in the validation or refutation of concerns expressed.

Where it has been investigated in simulated disturbance trials, the effects of dogs on wildlife were studied in the short-term for individual animals. A better understanding of long-term ramifications at the individual scale and the implications at the population scale will help managers meet the requirements of various wildlife species in the face of changing land-use patterns and human modifications to the environment. While research results will likely vary from setting to setting as in the eastern states, the results will help land and wildlife managers assess recreational impacts to wildlife species peculiar to western climates, physiography, and recreation patterns. Results would then be specific to wildlife species, their habitats, and the life history patterns that evolved in the Rocky Mountains. This lack of local insight provides all the more justification for managers to proactively consider domestic dogs in the recreation matrix.

Changing social values, perceptions, attitudes, and beliefs combine to create a dynamic and complicated operating environment for natural resource management agencies. Concurrently, human demographic trends, rural development, and increased outdoor recreation combine to create a changing landscape for wildlife. An enhanced understanding of the cumulative and synergistic effects of these trends by resource managers, integrated with an understanding of animal response, will help minimize impacts. Although very difficult to quantify and define, there may be thresholds at which recreational disturbance of any type (including presence of domestic dogs) transcends from the individual level to the population level. Those levels are unidentified at present.

LITERATURE CITED

Adrian, W. J., editor. 1981. Manual of common wildlife diseases in Colorado. Colorado Division of Wildlife, Denver, Colorado.
Baydack, R. K. 1986. Sharp-tailed grouse response to lek disturbance in the Carberry Sand Hills of Manitoba. Colorado State University, Fort Collins, Colorado.
Boyd, D. K., D. H. Pletcher, and W. Brewster. 1993. Evidence of wolves burying dead wolf pups. Canadian Field-Naturalist 107:230-231.
Burger, J. 1986. The effect of human activity on shorebirds in two coastal bays in northeastern United States. Environmental Conservation 13(2):123-130.
Chappel, R. W., and R. J. Hudson. 1978. Winter bioenergetics of Rocky Mountain bighorn sheep. Canadian Journal of Zoology 56:2388-2393.
Clark, R. K., and D. A. Jessup. 1992. Wildlife Restraint Series. International Wildlife Veterinary Services, Inc. Publications, Salinas, California.
Cochran, B. 1967. Delinquent dogs and dead deer. Outdoor Oklahoma 23(1):12-13.
Colorado Division of Wildlife. 1973. Dog killing deer problem grows. Colorado Division of Wildlife, Denver, Colorado.
Corbett, R. L., R. L. Marchinton, and C. E. Hill. 1971. Preliminary study of the effects of dogs on radio-equipped deer in a mountainous habitat. Proceedings of the Southeastern Association of Game and Fish Commissioners 25:69-77.
Cowan, D. 1999. Tracking the human footprint. Quarterly Journal of the Greater Yellowstone Coalition 6(1):6-9.
Denny, R. N. 1974. The impact of uncontrolled dogs on wildlife and livestock. Transactions of the North American Wildlife and Natural Resources Conference 39:257-291.
Dood, A. 1978. Summer movements, habitat use, and mortality of mule deer fawns in the Missouri breaks, Montana. Thesis, Montana State University, Bozeman, Montana.
Duda, M. D. 1995. Watching wildlife: tips, gear, and great places for enjoying America's wild creatures. Falcon Press Publishing, Helena, Montana.
Durden, L. A., and N. Wilson. 1990. Ectoparasitic and phoretic arthropods of Virginia opossums (*Didelphis virginiana*) in central Tennessee. Journal of Parasitology 76(4):581-583.
Fischer, H., and C. Fischer. 1990. Montana Wildlife Viewing Guide. Falcon Press Publishing, Helena, Montana.
Freddy, D. J. 1986. Responses of adult mule deer to human harassment during winter. R. D. Comer, T. G. Baumann, P. Davis, J. W. Monarch, J. Todd, S. VanGytenbeek, D. Wills, J. Woodling, editors. Proceedings II. Issues and technology in the management of impacted western wildlife: proceedings of a national symposium; February 4-6, 1985. Glenwood Springs, Colorado. Boulder, Colorado: Thorne Ecological Institute.
Freddy, D. J., W. M. Bronaugh, and M. C. Fowler. 1986. Responses of mule deer to disturbance by persons afoot and snowmobiles. Wildlife Society Bulletin 14(1):63-68.
Fuller, T. K. 1990. Dynamics of a declining white-tailed deer population in north central Minnesota. Wildlife Monographs 110.
Gavin, T. A., L. H. Suring, P. A. Vohs Jr., and E. C. Meslow. 1984. Population characteristics, spatial organization, and natural mortality in the Columbian white-tailed deer. Wildlife Monographs 91.
Gavitt, J. D. 1973. Disturbance effect of free-running dogs on deer reproduction. Thesis, Virginia Polytechnic Institute, Blacksburg, Virginia.
Giles, R. H., Jr. 1960. The free-running dog. Virginia Wildlife 21(6): 6-7.
Hanson, P., and T. A. Grant. 1991. The effects of human disturbance on trumpeter swan breeding behavior. Wildlife Society Bulletin 19:248-257.
Hoopes, E. M. 1993. Relationships between human recreation and piping plover foraging ecology and chick survival. Thesis, University of Massachusetts, Amherst, Massachusetts.
Houston, J. 1968. Dogs vs. deer. Colorado Outdoors 17(1):22-23.
Hulet, C. V., A. S. El-Sheikh, A. L. Pope, and L. E. Casida. 1956. The effect of shearing and level of feeding on fertility of rams. Journal of Animal Science 15:617-624.
Ingold, P., B. Huber, P. Neuhaus, B. Mainini, H. Marbacher, R. Schnidrig-Petrig, and R. Zeller. 1993. Tourism and sport in the alps – a serious problem for wildlife? Revue Suisse De Zoologie 100(3):529-545.
Keller, V. 1991. Effects of human disturbance on eider ducklings *Somateria mollissima* in an estuarine habitat in Scotland. Biological Conservation 58:213-228.

Knight, R. L., and D. N. Cole. 1995. Wildlife responses to recreationists. *In* R. L. Knight and K.J. Gurtzwiller, editors. Wildlife and recreationists: coexistence through management and research. 1995. Island Press, Washington D.C.

Leave No Trace. 1997. Do the wild thing! Leave no trace on open space brochure. Leave No Trace Skills and Ethics Series Volume 1.4, Boulder Colorado.

Lieb, J. W. 1981. Activity, heart rate, and associated energy expenditure of elk in western Montana. Dissertation, University of Montana, Missoula, Montana.

Lowry, D. A., and K. L. McArthur. 1978. Domestic dogs as predators on deer. Wildlife Society Bulletin 6(1):38-39.

MacArthur, R. A., V. Geist, and R. H. Johnston. 1979. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to the study of wildlife harassment. Canadian Journal of Zoology 57:2010-2021.

MacArthur, R. A., V. Geist, and R. H. Johnston. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. Journal of Wildlife Management 46(2):351-358.

Mainini, B., P. Neuhaus, and P. Ingold. 1993. Behavior of marmots *Marmota marmota* under the influence of different hiking activities. Biological Conservation 64(2):161-164.

Morrison, J. 1968. Hounds of hell. Georgia Game and Fish 3(12):13-19

Mosby, H. S. 1973. Personal communication, July 30, 1973. College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Nelson, T. A., and A. Woolf. 1987. Mortality of white-tailed deer fawns in southern Illinois. Journal of Wildlife Management 51(2):326-329.

Olliff, S. T., K. Legg, and B. Keading, editors. 1999. The effects of winter recreation on wildlife: a literature review and assessment, draft report. A report from the Greater Yellowstone Coordinating Committee Wildlife Working Group.

Parker, K. L., C. T. Robbins, and T. A. Hanley. 1984. Energy expenditures for locomotion by mule deer and elk. Journal of Wildlife Management 48(2):474-488.

Patterson, R. L. 1952. Sage Grouse of Wyoming. Wyoming Game and Fish Commission. Sage Books, Denver, Colorado.

Perry, M. C. 1970. Studies of deer-related dog activity in Virginia. Thesis, Virginia Polytechnic Institute. Blacksburg, Virginia.

Progulske, D. R., and T. S. Baskett. 1958. Mobility of Missouri deer and their harassment by dogs. Journal of Wildlife Management 22(2):184-192.

Renecker, L. A., and R. J. Hudson. 1986. Seasonal energy expenditure and thermoregulatory response of moose. Canadian Journal of Zoology 64:322-327.

Rudd, L. T., and L. L. Irwin. 1985. Wintering moose vs. oil/gas activity in western Wyoming. Alces 21:279-298.

Sarbello, W., and L. W. Jackson. 1985. Deer mortality in the town of Malone. New York Fish and Game Journal 32(2):141-157.

Shank, C. C. 1979. Human related behavioral disturbance to northern large mammals: a bibliography and review. Report prepared for Foothills Pipe Lines (South Yukon) Ltd., Calgary, Canada.

Shelton, M. 1964. Relation of environmental temperature during gestation to birth weight and mortality of lambs. Journal of Animal Science 23:360.

Sime, C. A. 1996. Population ecology of white-tailed deer in northwestern Montana. Job Progress Report, Montana Fish Wildlife and Parks, Helena. Federal Aid Project W-100-R-3.

Sime, C. A., and E. Schmidt. 1999. Off-site impacts of rural subdivision on wintering white-tailed deer in Northwest Montana: could man's best friend be wildlife's worst enemy? *In* 2001, A Space for Wildlife Odyssey: A Symposium on Living in the Western Landscape. 8-10 March, 1999, Bozeman, Montana. In Press.

Stuht, J. N., and W. G. Youatt. 1972. Heartworms and lung flukes from red foxes in Michigan. Journal of Wildlife Management 36(1):166-170.

Sweeney, J. R., R. L. Marchinton, and J. M. Sweeney. 1971. Responses of radio-monitored white-tailed deer chased by hunting dogs. Journal of Wildlife Management 35(4):707-716.

Thorne, E. T., N. Kingston, W. R. Jolley, and R. C. Bergstrom, editors. 1982. Diseases of wildlife in Wyoming. Second edition. Wyoming Game and Fish Department, Cheyenne, Wyoming.

Thrush, G. 1999. When I'm 64. American Demographics. January.

Ulberg, L. C., and P. J. Burfening. 1967. Embryo death resulting from adverse environment on spermatozoa or ova. American Society of Animal Science 26(3):571-577.

U. S. Department of Agriculture. 1996. Status of the Interior Columbia Basin: summary of scientific findings. U. S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Vincent, C. K., and L. C. Ulberg. 1965. Survival of sheep embryos exposed to high temperatures. Journal of Animal Science 24:931-932.

Ward, L. 1954. What's it going to be, deer or dogs in southern West Virginia? West Virginia Conservation 18(6):3-5.

Waterman, G., and L. Waterman. 1977. Dogs on the trail. Backpacker 5(4):29-32.

Watters, R. 1978. Ski trail and old timers' tales in Idaho and Montana. Solstice Press, Moscow, Idaho..

Westworth, D., L. Brusnyk, J. Roberts, and H. Veldhuzien. 1989. Winter habitat use by moose in the vicinity of an open pit copper mine I north-central British Columbia. Alces 25:156-166.

Williams, R. 1978. Energy crisis. Idaho Wildlife 1(6):33.

Yalden, P. E., and D. Yalden. 1990. Recreational disturbance of breeding golden plovers *Pluvialis apricarius*. Biological Conservation 51:243-262.

CHAPTER 9

VEGETATION, SOILS, & WATER

EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE
A Review for Montana

www.montanatws.org

MONTANA CHAPTER OF THE WILDLIFE SOCIETY

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ABSTRACT

Recreational activities can affect vegetation, soils, and water. These components of the environment would benefit from limiting of all off-highway vehicle (OHV) use to official routes, as well as devising timing and use standards for moderate, to high impact, non-motorized recreation areas. Additionally, all recreational activities should be carefully controlled and monitored in fragile and unique vegetation communities. Establishment of a monitoring system to determine the effect of various weed control methods on native vegetation could ultimately benefit wildlife habitat. Facilities should be developed where recreationists can wash weed seeds from sources of transportation. Limits should be established for personal watercraft and other two-stoke engines where ecological risk from toxic contaminants is to be avoided or reduced.

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The day does not seem wholly profane in which we have given heed to some natural object.
~~ Ralph Waldo Emerson ~~

INTRODUCTION

Vegetation, soil, and water, structurally arranged to meet the life-cycle necessities of wildlife, *is* wildlife habitat. The healthy function and interaction of these ecological components largely determines the well-being of wildlife populations. A brief discussion of vegetation, soils, and water is provided to initiate dialogue on this topic and to invite a more comprehensive synthesis of the extensive body of literature that exists relative to recreational impacts upon vegetation, soils, and water. The Montana Chapter of the Wildlife Society's (MCTWS) on-line bibliography that accompanies this project, currently houses over 520 references to vegetation, soil, and water that, to a large extent, focus on declining conditions resulting from recreational activities. The database will increase as additional references are located and new information becomes available, and is added to the database. Other professional societies or individuals with expertise in the arenas of botany, limnology, hydrology, soils, and fisheries are encouraged to provide updated, comprehensive chapters on these issues for inclusion on the MCTWS web site, or develop publications that may be referenced at the web site (www.montana.org).

Disturbances to landscapes induced by recreational activities were documented as early as 1935 by Bates who described mechanical damage to plants and changes in soil structure. Recreational impacts to vegetation can be extensive because recreationists disperse throughout large areas (Knight and Gutzwiller 1995), although the most visible impacts are generally near denuded trails, campsites and animal holding facilities (Cole 1987). Intensity of recreational use in some areas has resulted in water quality degradation potentially affecting human health (Christensen et al. 1979, NPS 1999). Activities in the name of leisure certainly have the ability to impact wildlife habitat, and possibly the biosphere. As Odum (1993) points out, "We need to learn a lot more about how the current real-world life-support systems of our earth function . . . so we can maintain the quality of these systems".

VEGETATION

Damage to Vegetation from Trampling

Vegetation is affected by trampling, which initially bends and weakens leaves and branches and ultimately breaks them. Trampling directly damages plants reducing photosynthetic surfaces, seed production, and carbohydrate reserves. It eventually kills some vegetation species. This changes community composition (Luckenbach and Bury 1983, Cole 1993). As soil compacts and erodes, roots are exposed and eventually killed (Liddle 1975, Hartley 1976). This level of disturbance allows the establishment of weed species (Mack 1986).

Leonard et al. (1985) determined that the greatest increase in plant mortality from trampling on simulated trails occurred at a low intensity of trampling, that is, between 100 and 300 passes on the simulated trail, with gradual increases in mortality at higher intensities. Frissel and Duncan (1965), LaPage (1967), Bell and Bliss (1973), Weaver and Dale (1978) provided data that corroborates Leonard et al. (1985) showing that loss of cover occurs most rapidly at the onset of disturbance.

Weaver and Dale (1978) compared trampling damage due to hikers, horses, and motorcycles in meadow and forest. Horses were most destructive on level ground, and going downhill, while motorcycles were most destructive on uphill slopes. There is more spinning on slopes than on level ground. Dale and Weaver (1974) showed that grass communities are more resistant to trampling than shrub communities. Bell and Bliss (1973) reported that alpine vegetation is very sensitive to trampling.

Significance of impact is related to rarity of the vegetation type, the value of the vegetation to wildlife species that depend on it, and to the potential to de-stabilize soils (Cole and Landres 1995). Trails along streams negatively affect riparian vegetation with concurrent increases in sedimentation to adjacent streams. Sediments can inhibit or kill periphyton communities, bacteria, and fungi, which are important food sources for invertebrates, amphibians, and fish (Cardone and Kelly 1961, Murphy et al. 1981).

Damage to Vegetation from Snowmobiles and OHVs

Snowmobile impacts appear to be greater in forest communities than in open areas, partially because snow drifting fills in the tracks in open areas (Wanek 1971). One traverse over undisturbed snow can affect the physical environment beneath the snow and physically damage important plants. Snow compaction lowers soil temperatures and reduces the survival of plants and soil microbes. The impact of snowmobiling on the biota varies with the depth of snow accumulation, the intensity of snowmobile traffic, and the susceptibility of the organism to injury caused by cold temperatures or physical contact. Temperatures beneath snow compacted by snowmobiles are considerably colder than those under undisturbed snow cover. Thus the growth and reproductive success of early spring flowers is retarded and reduced where snowmobiles travel. Herbs with large underground storage organs are winter-killed under snowmobile tracks. Woody plants are particularly vulnerable to physical damage by snowmobiles (Wanek 1973). Bury (1978) noted that "the greater the torque applied at the machine/environment interface, the greater the potential for impact." Boucher and Tattar (1975) reported that disruption to plants under snowmobile trails was most heavy on south-facing slopes exceeding 30 degrees incline. On steep slopes, shallow roots and rhizomes were damaged. Neumann and Merriam (1972) also showed that direct mechanical effects by snowmobiles on vegetation at and above snow surface can be severe. After only a single pass by a snowmobile, more than 78% of the saplings on the trail were damaged, and nearly 27% of them were damaged seriously enough to cause a high probability of death. Although Neumann and Merriam (1972) indicated that it is difficult to predict whether whole ecosystems will be affected by snowmobiling, they state that "management of snowmobiles as a factor in the human environment should not await this purely ecological information."

Vegetation suffers directly and indirectly from the passage of off-road vehicles (ORVs). The effects can last decades or even centuries (Blackburn and Davis 1994). A report by White House council on Environmental Quality entitled "Off-Road Vehicles on Public Land" states, "ORVs have damaged every kind of ecosystem found in the United States: sand dunes covered with American beach grass on Cape cod; pine and Cyprus woodlands in Florida; hardwood forests in Indiana; prairie grasslands in Montana; chaparral and sagebrush hills in Arizona; alpine meadows in Colorado; conifer forests in Washington; arctic tundras in Alaska. In some cases the wound will heal naturally; in others they will not, at least for millennia" (Pica et al. 1998). Blackburn and Davis (1994) states, "There is a strong correlation between damage to soil and damage to vegetation. Compaction and erosion, for instance, influence the ability of plants to take up nutrients and carbon dioxide, experience proper root growth, and have enough stability to grow upwards…. Unless regulations exist and are strictly enforced, users will choose their own routes and hillclimb areas. Unfortunately, they select areas for their challenge, not for their soil type and stability."

A controlled study by Leininger and Payne (1971) showed that forbs were damaged by all-terrain vehicles (ATVs) most significantly in early fall. Shrubby species were impacted most during spring and early summer. Graminoids were least affected from vehicle travel. Eight passes with a vehicle caused significant loss of shrub cover. Vegetation was completely destroyed after 32 passes with the vehicle. In a study of the impact of ORV use on valley vegetation in West Virginia, Stout (1992) indicated that valley grasses tend to replace the shrubs that have been destroyed. Blackburn and Davis (1994) stated, "Direct and indirect impacts add up to a transformation of plant communities for the worse. Communities on a site prior to human disruption are composed of a variety of species adapted to that particular habitat. They live together in a relatively stable balance. ORVs and other severe disruptions destroy the balance and make it impossible for the plants to continue to coexist. Some plants are better able to endure the presence of ORVs than others. The adaptable plants are likely to have root systems that survive compaction. These plants flourish while more sensitive species disappear."

Recreational Activities and Weeds

Uncontrolled and largely unmanaged trail systems, spreading across public lands, provide an expeditious avenue for weed dispersal. Recreational activities may introduce and encourage weeds. Hay for pack animals and the resulting excrement are sources of weed seeds. Backpackers may import seeds on their equipment, and motorized vehicles are capable of distributing weed seeds (Kummerow 1992). Rapid dispersal of weeds is characteristic of motorized routes where a vehicle in one trip, can spread 2,000 knapweed seeds over a 10-mile course (Montana State University Extension Service Bulletin 1992). Although dispersal of weeds is a prodigious issue, disturbance of soils by vehicles has long-term effects that favor the establishment of weedy species (Blackburn and Davis 1994).

After disturbance, weedy, often exotic species, are likely to gradually crowd out native vegetation; thus biodiversity may be drastically lowered (Stout 1992).

Given establishment, the current political climate demands that we kill weeds with potent herbicides. In Montana all land management agencies are operating under state legislative mandates that weeds be "controlled." Thus the war on weeds is being conducted by an army of personnel with backpack sprayers, tanks on ATVs, larger tanks mounted on trucks with boom-mounted applicators, as well as aerial spraying. Tons of diverse herbicides are infused into the environment.

One hypothesizes that this generalized approach will remove all forbs, and allow noxious forbs known to be especially invasive, to re-invade with greater force. Two studies support this idea. Long-term (20 year) observations of a fescue-grassland sprayed for spurge, show a good initial kill of all forbs, a strong reinvasion of spurge, but no reinvasion of native forbs (B. Maxwell and T. Weaver, professors in weed science and biology, Montana State University, personal communication). Long-term (30 year) observations of *Abies lasiocarpa*/*Vaccinium scoparium* habitat types sprayed to minimize understory development and encourage tree establishment, have some herbs and grasses in the understory, but no shrubs. Further testing is critically important before widespread non-directed spraying can be justified. Such testing could be made by analyzing previously sprayed sites or requiring applicator follow-up to monitor incidental effects on native plants by their treatments.

SOILS

Erosion, Compaction, and Rutting of Soils

Soil impacts caused by recreation depend on soil type, vegetation cover, topography, and intensity of use (Weaver and Dale 1978). Recreational impacts to soils are found at picnic areas and campgrounds, low-standard roads, trails, and off-road. The primary detrimental soil impacts are loss of productivity, erosion, compaction, rutting, and displacement.

Soils derived from parent materials such as granitics, coarse-grained volcanics, or gneisses are sandy and easily erode when organic layers or vegetative cover is removed. This condition is made worse by moderately steep or steeper slopes and south to west aspects (National Soil Survey Handbook 1996.) Erodibility describes a soil's susceptibility to erosion and is influenced by properties such as texture, structure, organic matter content, and chemical make-up (Lal and Elliot 1994). Erosion can be so severe that soil-surface horizons are lost, and long-term soil productivity is decreased. The process of physically detaching and transporting soil particles, can be further accelerated by a decrease in infiltration capacity associated with horse and off-highway vehicle (OHV, includes full-sized vehicles as well as ATVs) use (Satterlund and Adams 1992).

Off-road vehicles exert shear stress parallel to the soil surface, as well as compressive stress (Wilshire et al. 1978). Direct effects of sheer and compression stress include crushing of foliage, root systems, and seedlings, and uprooting and disruption of root systems of larger plants by shear stresses to the soil. Indirect effects include undercutting of root systems as vehicle paths are enlarged by erosion, creation of new erosion channels on land adjacent to vehicle-destabilized areas due to accelerated runoff or wind erosion, burial by debris eroded from areas used by vehicles, and reduction of biological capability of the soil by physical modification and stripping of the more fertile upper soil layers. There are two basic responses in soils from OHV use (Sheridan 1979, cited in Blackburn and Davis 1994): "One, sandy and gravelly soils are susceptible to direct quarrying by ORVs, and when stripped of vegetation they are susceptible to rapid erosion processes – usually by rill and gully erosion. Two, more clay-rich soils are less sensitive to direct mechanical displacement by ORVs, but the rates of erosion of stripped clay-rich soil are much higher under ORV use than under natural conditions." Also, pounding of the latter creates strong seal on the surface, which reduce water infiltration. This causes gullying lower in the drainage due to greater rainwater runoff (Sheridan 1979).

As with agricultural soils, conservation of soils in ORV areas requires intensive on-site management (Wilshire et al. 1978). The standards of tolerable soil loss (in tons/acre/year) set forth by the SCS (USDA 1977, cited in Wilshire et al. 1978) are predicated on retention of a long-term designated level of biological productivity of the land. Protection of public lands used by ORVs (Executive Orders 11644, 11989 – see Appendix D of this report) may be accomplished under the same concept of loss tolerances devised from long experience and research with agricultural uses of soil. Application of such standards, of course, requires a thorough description of the soil resources of the areas of intended use and intensive management to control and monitor the levels of deterioration (Executive Order 11644, Geological Society of America 1977) so that the designated level of permissible loss is not exceeded. The problems of rapid deterioration of vegetation and soil are most severe in the upland and arid areas most commonly selected for vehicle use in the west (Wilshire et al. 1978).

Shallow water tables associated with riparian areas are especially susceptible to detrimental rutting, erosion, displacement, and compaction when they are crossed by low-standard roads, trails, or used for off-road travel by horses, mountain bikes, motorcycles, ATVs , and full size vehicles. Intense recreational use of these areas can lead to increased streambank erosion, bank failure, and loss of wetland function including water storage and sediment trapping (Federal Interagency Stream Restoration 1998). Soils in semi-arid and arid areas are also impacted by off-road vehicles, mountain bikes, and foot traffic. Once the soil surface and microbiotic crusts are disturbed, erosion by wind, rain and gravity increase (Johnston 1997). Soil compaction from even moderate traffic increases runoff and soil displacement, causing concentrations of water that make erosive forces more effective (Alexander and Poff 1985). Reestablishment of crusts may require hundreds of years (Blackburn and Davis 1994).

Alexander and Poff (1985) cite studies of soil compaction at campgrounds and picnic areas throughout the United States. Increases in soil-bulk density as a result of compaction ranged from 8 to more than 46%. These levels of compaction reduce water infiltration, increase runoff, limit the ability of vegetation to reestablish, and result in an overall loss of soil productivity. Vegetation recovers little 20 years after one summer of trampling in an *Abies/Vaccinium scoparium* habitat type (T. Weaver and D. Dale, professors of weed science and biology, Montana State University, personal communication). Wanek's (1971) research indicated that bacterial decomposers and litter decomposition may be significantly affected by roads. Wilshire et al. (1978) indicates that a four-wheel drive vehicle with a track 47 cm wide will impact at least a hectare of ground for every 23 km traveled. In contrast, the average motorcycle track is 13 cm wide, and impacts a hectare every 77 km.

Mass failures, such as landslides, occur naturally, but roads dramatically increase their frequency and magnitude, from several times to hundreds of times (Furniss et al. 1991). Such failures can be a major sediment source detrimental to insects and fish of nearby streams (Swanson and Dyrness 1975, Beschta 1978).

WATER

<u>Water Quality and Quantity Issues Related to Roads</u>

Roads have been identified as <u>the</u> major impact on the forest environment (Johnson 1995). Natural drainage patterns can be disrupted by roads when water is diverted and prevented from infiltrating into soils (Bagley 1998). Impacts from roads basically fall into three areas: introduced sediment into streams; snowmelt re-direction and concentration, and surface flow production (Johnson 1995). Roads can affect both the volume of water available as surface runoff and the efficiency by which water flows through a watershed (Wemple et al. 1996). Roads accelerate water flows and sediment transport, which raise flood levels and degrade aquatic ecosystems. Local hydrologic and erosional effects along roads are dispersed across the land, whereas major impacts are concentrated in the stream network and distant valleys (Forman and Alexander 1998). Bagley (1998) states, "Roads increase the volume of surface runoff in two ways. First, compacted road surfaces do not readily absorb water. And, second, road cuts intercept subsurface water flow and convert it to surface flow. Water moving through a watershed as surface runoff moves more quickly because it has less resistance to flow compared to water percolating through soil. The faster surface runoff causes accelerated soil erosion. Roads thus increase water reaching stream channels during a storm and snowmelt events, so channels must accommodate the additional volume of water and road-related sediment. More water and sediment in channels alter their physical structure, usually with negative effects on aquatic habitat."

Aquatic ecosystems are impacted by sediments from roads as well as the large water flushes just described. Road surface drainage, and the sagging of road ditches into channels and creeks, is a common Best Management Practice (BMP) violation, and the dwindling national forest road maintenance budget makes it difficult to maintain culvert crossings (Johnson 1995). Sediment originating from roads reach streams and rivers, degrading habitat and impairing fish reproduction (Harr and Nichols 1993). Fine sediments impact spawning habitat by settling into and covering spawning gravels, and interfering with salmonid redd (nest) construction. Excessive sediments can impede intergravel water flow that provides oxygen and removes waste products, both of which are necessary for successful egg development. Roads thus increase barriers to migrating adult and juvenile salmonids and the macroinvertebrates they depend on (Furniss et al. 1991). When culverts fail during storm and runoff events, tremendous amounts of sediment can be delivered directly to the channel and from there down into lower streams, potentially affecting sensitive fish habitat (Johnson 1995). Johnson (1995) notes that "Even on roads that appear to be so thick with alder that a sediment production concern seems ludicrous, we often find that the road tracks are still actively functioning as erosion sources."

Spring snowmelt and runoff from frequent mid-winter melt and rain-on-snow events that would normally travel in a downhill direction, usually as shallow sub-surface flow, is intercepted by the compacted roads and their ditches and becomes surface flow (Johnson 1995). Thus the drainage efficiency of a watershed is dramatically increased (Johnson 1995). In a study of hydrologic interaction of forest roads with stream networks, it was pointed out that the contributions of the road and ditch network provides a substantial peak in water runoff flows, and may extend the stream network by as much as 40% (Wemple 1994). Carlston (1963) developed an equation to measure the mean annual flood and its variability with stream density. Using Wemple (1994) and Carlston's (1963) work, Johnson (1995) found that flows would almost double (1.96 times) where the road density was only 1.61 mi/mi^2. He notes that in many watersheds, particularly where attempts are being made to remove or obliterate older roads (including jammer-logging trails, major skid-trails), there are road densities that exceed 20 mi/mi^2. Thus drainage efficiency can be expected to be an order of magnitude or more greater than on less roaded landscapes. Hollis (1975) found dramatic increases in the size of floods related to impervious surfaces. He notes that small floods may be increased 10 times, and the 100-year flood may be doubled in size when drainage is basin-wide and 30% has been paved (left with impervious surfaces). When only 6% of the watershed was compacted, Harr (1986) notes significant peak flow increases, and emphasizes that building and locating roads so as to not intercept and re-direct water is very important.

Shallow subsurface water can be converted to surface flow when intercepted by road cuts that exceed a few feet in height (Johnson 1995). Amounts vary by soil material, but surface flow volumes are increased substantially when sub-surface flows are intercepted by roads. Wemple (1994) concluded that modifying road segments was the most effective way to approach watershed restoration.

Snowpack Issues Related to Use of Snowmobiles

Compacted snow melts rapidly and retains water less well than non-compacted snow (Neumann and Merriam 1972). Neumann and Merriam (1972) note that, after compaction by snowmobiles, snow melting times increased to as much as double, and the potential water-holding capacity of snow compacted by snowmobiles was reduced substantially throughout the profile. During spring melt, these effects could significantly reduce the ability of snow to slow runoff and to moderate the effects of thawing.

Water Quality Issues Related to Backcountry Use

The relative expanse of most remote areas is misleading. Most use of remote areas is concentrated in the most accessible portions. Even in 1968, tons of chemicals were being introduced to the Boundary Waters Canoe Area, where 75% of the visitors entered the area through only 8 of the 66 entry points (Barton 1969). National forest wilderness growth exceeds growth for many other forms of recreation taking place in the national forests (Hendee et al. 1990). As a percentage of total national forest recreation use and of national forest campground use, wilderness use has grown steadily and only recently has shown a decline (other types of recreation have also leveled off or declined since 1980) (Hendee et al. 1990). Continued population expansion and increased leisure time and affluence will require that wilderness areas absorb greater use. Barton (1969) notes that special standards must be formulated and strictly enforced in wilderness areas and tributary drainages if man's impact on these areas is to be minimized.

Water Quality Issues Related to Use of Personal Watercraft

Nearly all personal watercraft (PWC) utilize conventional two-stroke engines. As much as 30% of the fuel taken in by these engines is never used and is discharged, unburned, into water (California Environmental Protection Agency

1999). As much as 4 out of 10 gallons of gasoline that are ingested by an outboard motor, may be discharged, unused, into the water (Muratori 1968, Stewart and Howard 1968). The use of leaded gasoline may result in lead accumulations in bottom mud that interrupt decomposition cycles and the food chain. Outboard motor gasoline also contains oil that contribute specific pollution problems to water: one gram of oil requires 3.3 grams of oxygen for complete oxidation, oil slicks interfere with gas exchange on the air-water surface, and oil also contains phosphates (Muratori 1968, Stewart and Howard 1968). The combustion process discharges additional toxic compounds into water. As a result, the use of PWCs has resulted in lower water quality in the nation's lakes and reservoirs (NPS 1999).

Based on average use, a typical conventional two-stroke outboard or PWC will expel as much as 30% of the incoming fuel mixture, unburned, via the exhaust. Also known as "two-cycle" engines, these motors intake a mixture of air, gasoline, and oil into the combustion chamber while exhaust gases are being expelled from the combustion chamber. Because the intake and exhaust processes are occurring at the same time, it is unavoidable that some of the unburned fuel mixture will escape with the exhaust. This expulsion of unburned fuel is the reason for the elevated levels of hydrocarbon emissions from conventional two-stroke engines. For example, at common fuel consumption rates, an average two-hour ride on a PWC may discharge three gallons of the gas-oil mixture into the water (NPS 1999).

Methyl tertiary butyl ether (MTBE) and polycyclic aromatic hydrocarbons (PAHs) are commonly observed two-stroke engine contaminants and pose the most serious threats to human and ecological health. Water treatment facilities are generally ineffective in reducing MTBE concentrations. Aquatic ecological communities do not appear to be threatened by observed concentrations of MTBE; however, more research is needed to reinforce this conclusion (NPS 1999).

The concentrations of PAH in lakes and reservoirs with high motorboat activity have been found at levels dangerous to aquatic organisms (NPS 1999). The concentrations causing adverse effects can be extremely low (parts-per-trillion range) due to PAH phototoxicity, especially in oligotrophic waters where sunlight penetration is high. The concentrations of PAH in lakes and reservoirs with high motorboat activity also have been found at levels dangerous to human health where humans are drinking the water and/or consuming the fish from these waters. Although PAH concentrations have not been widely measured, there is no reason to believe that the concentrations quoted are not widespread in lakes or reservoirs with high motorboat activity.

Management strategies adopted by other agencies include outright bans on PWC and restricted use of two-stroke motors. The exclusive use of the newly introduced and less polluting, direct-injection two-stroke engines has also been examined by water management agencies. One strategy for avoiding toxins in surface waters is to draw relatively uncontaminated water from deeper intervals to supply drinking water, but the consequences of this action upon amphibians, fish, insects, and algae has not been reported.

CONCLUSIONS

Impacts to vegetation, soil, and water by recreational activities have been well documented for six decades, in many community types, in all seasons, and on all continents. Putting available information to use is the challenge. "When the 'study of the household' (ecology) and the 'management of the household' (economics) can be merged, and when ethics can be extended to include environmental as well as human values, then we can be optimistic about the future of humankind" (Odum 1993). Respect for vegetation, soils, and water, and ensuring the proper function of life-support systems, is fundamental to the health and well-being of wildlife, now, and in the future.

GUIDELINES/RECOMMENDATIONS

1. Prohibit OHV use off of officially designated routes.
2. Restrict non-motorized uses (hikers, horses, mountain bikes, etc.) to trails in heavy-use areas.
3. Restrict specific activities in fragile and unique plant communities (Bell and Bliss 1973, Dale and Weaver 1974).

4. Properly site roads and trails to minimize soil erosion, and close or relocate routes that deliver unacceptable sediment loads to streams (Wemple 1994).
5. Monitor various weed control methods and their effect on native vegetation.
6. Develop facilities for users of OHVs, horses, and other modes of transportation, to clean away weed seeds.
7. Restrictions on use in wilderness and back-country areas may be necessary to protect water quality and other resources; at the same time, monitoring systems to evaluate controls should be implemented to measure chemical, biological, bacteriological, physical, and aesthetic properties (Barton 1969).
8. Establish limits of use for PWCs and other two-stroke motors where known toxic thresholds of MTBE and PAHs are approaching ecological risk (NPS 1999) .
9. Restrict use of two-stroke motors in small or shallow bodies of water, or in identified sensitive areas in rivers, larger lakes, or reservoirs.

INFORMATION NEEDS

Recreational activities can and do impact wildlife habitat. Levels and types of recreational activity that may be allowed in sensitive areas throughout Montana can be determined by comparing areas of functional, intact habitats and other areas where detrimental changes have already occurred. Monitoring with built-in checkpoints for corrective action, could prevent institutionalization of damaging recreational activities. Specific instances may exist where pure waters, fragile soils, or rare vegetation dictate that recreational disturbance not occur at all. Prudence by natural resource managers would result in prompt decisions to protect the environment, and correct damaging activities or potentially damaging situations; managers should not delay decisions while awaiting results of definitive ecological research.

Tools are needed for resource and recreational managers to determine where, to what degree, and what types of recreational activities may be allowed across Montana landscapes, without detrimental consequences to wildlife habitat. For example, the consequences to watersheds experiencing snow compaction at varying levels as a result of snowmobile use, should be determined. An inventory of natural resource maps and sensitive species distributions should be assembled to define areas in the state that must have an order of protection over and above areas where fundamental criteria should already be in place. Management options might include seasonal avoidance areas by all recreationists, and perhaps diurnal-timing restrictions for recreationists on seasonally important wildlife areas.

LITERATURE CITED

Alexander, E. B., and R. Poff. 1985. Soil disturbance and compaction in wildland management. U.S. Forest Service, Pacific Southwest Region, Watershed Management Staff. Earth Resources Monograph B.

Bagley, S. 1998. The Road-Ripper's Guide to Wildland Road Removal. Wildlands Center for Preventing Roads. 40pp.

Barton, M. A. 1969. Water pollution in remote recreational areas. Journal of Soil and Water Conservation 24(4):132-135.

Bates, G. H. 1935. The vegetation of footpaths, sidewalks, cart-tracks, and gateways. Journal of Ecology 23:470-487.

Bell, K., and L. Bliss. 1973. Alpine disturbance studies: Olympic National Park, USA. Biological Conservation 5:25-32.

Beschta, R. 1978. Long-term patterns of sediment production following road construction and logging in the Oregon Coast Range. Water Resour. Res. 14:1011-1016.

Blackburn, J., and M. Byrd Davis. 1994. Off-road vehicles: fun and/or folly. Livingston, Kentucky. ASPI Publications. 56pp.

Boucher, J., and T. A. Tattar. 1975. Snowmobile Impact on Vegetation. Pages 27-28 *in* Forest Notes 1974-1975.

Bury, R. L. 1978. Impacts of snowmobiles on wildlife. Trans. N. Amer. Wildl. Nat. Res. Conf. 43:149-156.

California Environmental Protection Agency, Air Resources Board, 1999. Fact Sheet -- New Regulations for Gasoline Engines, http://www.arb.ca.gov/msprog/marine/marine.htm.

Cardone, A. J., and D. E. Kelly. 1961. The influence of inorganic sediment on the aquatic life of streams. California Fish and Game 47:189-228. Referenced in: Knight, R.L. and K.J. Gutzwiller, eds. 1995. Wildlife and Recreationists: Coexistence Through Management and Research. 1995. Island Press, Washington, D.C.

Carlston, C. W. 1963. Drainage density and streamflow. U.S. Geological Survey Professional Paper 422-C, Physiographic and Hydraulic Studies of Rivers.

Christensen, H. H., R. E. Pacha, K. J. Varness, and R. F. Lapen. 1979. Human use in a dispersed recreation area and its effect on water quality. Pages 107-119 *in* Ittner, D. R. Potter, J. K. Agee, and S. Anschell, eds. Recreational impacts on wildlands. U.S. Forest Service and National Park Service, Washington, D.C. R-6-001-1979.

Cole, D. N. 1987. Research on soil and vegetation in wilderness: a state-of-knowledge review. Pages 135-177 *in* Lucas, R. C., compiler. Proceedings – National Wilderness Research Conference: Issues, State-of-knowledge. Ogden, UT. Intermtn. Res. Station U.S. Forest Service. Genl. Tech. Rept. INT-220.

Cole, D. N. 1993. Trampling effects on mountain vegetation in Washington, Colorado, New Hampshsire, and North Carolina. U.S. Forest Service Research Paper INT-464, Ogden, Utah. Intermountain Research Station. Referenced in: Knight, R.L. and K.J. Gutzwiller, eds. 1995. Wildlife and Recreationists: Coexistence Through Management and Research. 1995. Island Press, Washington, D.C

Cole, D. N., and P. B. Landres. 1995. Indirect effects of recreation on wildlife. Pages 183-202 *in* Knight, R. L. and K. J. Gutzwiller, eds. Wildlife and Recreationists: Coexistence Through Management and Research. 1995. Island Press, Washington, D.C.

Dale, D., and T. Weaver. 1974. Trampling effects on vegetation of the trail corridors of north Rocky Mountain forests. Journal of Applied Ecology 11:767-772.

Federal Interagency Stream Restoration Working Group. 1998. Stream Corridor Restoration, Principles, Processes, and Practices.

Forman, R. T. T., and L. E. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics 29:207-231

Frissel, S. S., Jr., and D. P. Duncan. 1965. Campsite preference and deterioration in the Quetico-Superior canoe country. Journal of Forestry. 63:256-260.

Furniss, M. J., T. D. Roelofs, and C. S. Yeel 1991. Road construction and maintenance. Chapter 8 *in*: Influences of forest and rangeland management on Salmonid fishes and their habitats. American Fisheries Society Special Publication 19:297-323.

Geological Society of America. 1977. Impacts and management of off-road vehicles. Committee on Environment and Public Policy, Geological Society of America. Boulder, Colorado: 8 pp.

Harr, R. D., and R. A. Nichols. 1993. Stabilizing forest roads to help restore fish habitats: a Northwest Washington example. Fisheries 18(4):18-22.

Hartley, E. A. 1976. Man's effects on the stability of alpine and subalpine vegetation in Glacier National Park, Montana. Dissertation. Duke University. Durham, North Carolina. Referenced in: Knight, R. L. and K. J. Gutzwiller, eds. Wildlife and Recreationists Coexistence Through Management and Research. 1995. Island Press, Washington, D.C.

Hendee, J. C., G. H. Stankey, and R. C. Lucas. 1990. Wilderness Management. North American Press, Fulcrum Publishing, Golden, Colorado. 546pp.

Hollis, G. E. 1975. The effect of urbanization on floods of different recurrence intervals. Water Resources Research 11(3):431-435.

Johnson, S. R. 1995. Factors supporting road removal and/or obliteration. Memo from Forest Hydrologist to Fire Recovery Hydrologists. Kootenai National Forest. 5pp.

Johnston, R. 1997. Introduction to microbiotic crusts. U.S. Natural Resources Conservation Service, Soil Quality Institute.

Knight, R. L. and K. J. Gutzwiller, eds. 1995. Wildlife and Recreationists: Coexistence Through Management and Research. Island Press, Washington, D.C.

Kummerow, M. 1992. Weeds in the wilderness: a threat to biodiversity. Western Wildlife 18(2)12-17.

Lal, R., and W. Elliot. 1994. Erodibility and erosivity. *In* Lal, R. (ed.). 1994. Soil erosion research methods. St. Lucie Press, Delray Beach, FL.

LaPage, W. F. 1967. Some observations on campground trampling and ground cover response. Res. Pap. NI-68. Upper Darby, PA/ U.S. Forest Service, Northeastern Forest Experiment Station. 11pp.

Leininger, W. C., and G. F. Payne. 1979. The effects of off-road vehicle travel on rangeland in southeastern Montana. Agricultural Experiment Station, Montana State University. Research Rept. 153. 47 pp.

Liddle, M. J. 1975. A selective review of the ecological effects of human trampling on natural ecosystems. Biological Conservation 7:17-36. Referenced in: Knight, R. L. and K. J. Gutzwiller, eds. Wildlife and Recreationists: Coexistence Through Management and Research. 1995. Island Press, Washington, D.C

Leonard, R. E., J. L. McMahon, and K. M. Kehoe. 1985. Hiker trampling impacts on eastern forests. U.S. Forest Service Res. Paper NE-55. Northeastern Forest Experiment Station.

Luckenbach, R. A., and R. B. Bury. 1983. Effects of off-road vehicles on the biota of the Algodones Dunes, Imperial County, California. Journal of Applied Ecology 20:265-286. Referenced in: Knight, R.L. and K.J. Gutzwiller, eds. Wildlife and Recreationists: Coexistence Through Management and Research. 1995. Island Press, Washington, D.C.

Mack, R. N. 1986. Alien plant invasion into the Intermountain West: a case history. Pages 191-213 i*n* Ecology of Biological Invasions of North America and Hawaii. H. A. Mooney and J. A. Drake, eds. New York:Springer-Verlag. Referenced in: Knight, R. L. and K. J. Gutzwiller, eds. Wildlife and Recreationists: Coexistence Through Management and Research. 1995. Island Press, Washington, D.C.

Montana State University Extension Service Bulletin. 1992. Controlling knapweed on Montana rangeland. Circular 311, February 1992.

Muratori, A. Jr. 1968. How outboards contribute to water pollution. The Conservationist 22(6):6-8.

Murphy, M. L., C. P. Hawkins, and N. H. Anderson. 1981. Effects of canopy modification and accumulated sediment on stream communities. Transactions of the American Fisheries Society 110:469-478.

National Park Service. 1999. Water quality concerns related to personal watercraft usage. Draft internal literature review. Water Resources Division, National Park Service. 11pp.

National Soil Survey Handbook. 1996. Soil Survey Staff. Natural Resources Conservation Service. Wash., D.C.

Neumann, P. W., and H. G. Merriam. 1972. Ecological effects of snowmobiles. The Canadian Field-Naturalist 86:207-212.

Odum, E. P. 1993. Ecology and our endangered life-support systems, 2nd Edition. Sinauer Associates, Inc., Sunderland, Massachusetts. 301pp.

Pica, E., J. Smith, and G. Kripke. 1998. Trails of destruction – how off-road vehicles gain access and funding on public lands. A report by Friends of the Earth and Wildlands Center for Preventing Roads. 30pp.

Satterlund, D. R. and P. W. Adams. 1992. Wildland watershed management, 2nd edition. John Wiley and Sons, Inc. New York, NY. Referenced in S. Bagley. 1998. The Road-Ripper's Guide to Wildland Road Removal. Wildlands Center for Preventing Roads. 40pp.

Sheridan, D. 1979. Off-road vehicles on public land. Council on Environmental Quality. Washington, D.C.

Stewart, R. H. and H. H. Howard. 1968. Water pollution by outboard motors. The Conservationists 22(6):6-8.

Stout, B. M. III. 1992. Impacts of off-road vehicle use on vegetative communities of Northern Canaan Valley, West Virginia. Prepared for The Canaan Valley Task Force. Final Report. Pp.12-13.

Swanson, F. J., and C. T. Dyrness. 1975. Impact of clear-cutting and road construction on soil erosion by landslides in the western Cascade Range, Oregon. Geology 3:393-96

U.S. Department of Agriculture. 1977. Guide to erosion and sediment control. U.S. Soil Conservation Service, Davis, California. 32pp.

Waller, A., C. Sime, and G. Bissell. 1999. Semi-aquatic mammals. Pages 5.1-5.25 *in* G. Joslin and H. Youmans, editors. The effects of recreation on Rocky Mountain Wildlife: A review by the Montana Chapter of the Wildlife Society. Committee on the Effects of Recreation on Wildlife. Montana Chapter of the Wildlife Society. 325pp.

Wanek, W. J. 1971. Snowmobiling impact on vegetation, temperatures and soil microbes. Pages 117-130 i*n* Proceedings of The Snowmobile and Off-the-Road Vehicle Research Symposium. Michigan State Univ.

Wanek, W. J. 1973. The ecological impact of snowmobiling in northern Minnesota. The Center for Environmental Studies. Bemidji State College, Bemidji, MN. Pp.57-76.

Weaver T. and T. Dale. 1978. Trampling effects of hikers, motorcycles and horses in meadows and forests. Journal of Applied Ecology 15:451-457.

Wemple, B. C. 1994. Hydrologic integration of forest roads with stream networks in two basins, Western Cascades, Oregon. Oregon State University MS Thesis.

Wilshire, H. G., S. Shipley, and J. K. Nakata. 1978. Impacts of off-road vehicles on vegetation. Trans. N. Amer. Wildl. Nat. Resource Conf. 43:131-139.

CHAPTER 10

INFORMATION REGARDING THE ONLINE BIBLIOGRAPHY

EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE

A Review for Montana

www.montanatws.org

MONTANA CHAPTER OF THE WILDLIFE SOCIETY

Written by

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ABSTRACT

The Montana Chapter of the Wildlife Society initiated a project in September 1997 to prepare an annotated bibliography on the effects of recreation on wildlife, focusing on species of amphibians, reptiles, birds, and mammals (excluding bison) in Montana. The result of this project is an online bibliographic database that can be accessed from the Montana Chapter of the Wildlife Society's home page (http://www.montanatws.org). Copies of all papers obtained for the bibliography are available for public use at the Montana State Library.

<u>Suggested citation for this chapter</u>

Waller, A. J. 1999. Information Regarding the Online Bibliography. Pages 10.1-10.5 *in* G. Joslin and H. Youmans, coordinators. Effects of recreation on Rocky Mountain wildlife: A Review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society. 307pp.

OVERVIEW

The Montana Chapter of the Wildlife Society (MCTWS) initiated a project in September 1997 to prepare an annotated bibliography on the effects of motorized and non-motorized recreation on wildlife and wildlife habitat, focusing on free-ranging species of wildlife in Montana. References that directly address the effects of recreation and disturbance on amphibians, reptiles, birds, and mammals (excluding bison) were compiled from September 1997 – September 1999. The bibliography also includes select papers that provide important background information on species' behavior, physiology, and habitat requirements. The bibliography is available online and can be accessed from the MCTWS web site (http://www.montanatws.org). The bibliography can be searched by wildlife groups (amphibians and reptiles, birds, carnivores, semi-aquatic mammals, small mammals, ungulates), types of motorized and non-motorized recreation, and other keywords such as specific wildlife species, vegetation, soil, water, and policy. Detailed search instructions and a list of keywords are available with the online bibliography. Users can export the entire bibliography or specific search results in tagged format to import into bibliographic management programs.

In general, references included in the bibliography were selected from literature searches of commercial and noncommercial reference databases, other recreation bibliographies, and literature cited in relevant publications. The most recent bibliographies or literature reviews that were primary sources of information include Bennett (1995), Biodiversity Legal Foundation (1996), Caslick and Caslick (1999), Colorado State Parks (1998), Singleton (1999), U.S. Fish and Wildlife Service (1995), Williams and Lester (1996), and York (1994). Additional references were identified from literature searches conducted for this project by the U.S. Forest Service (USFS) Rocky Mountain Research Station Library-Ogden Center, U.S. Geological Survey (USGS) Biological Resources Division Library, Bureau of Land Management (BLM) Library, and the Montana State Library (MSL). Online databases available to the public and commercial databases accessible through the University of Montana (UM) Mansfield Library were also searched. A complete list of all CD-ROM or online databases searched is given in Table 1. The databases were searched for variations and different combinations of the following keywords: aircraft, airplane, angling, antler collecting, ATV, all terrain, backpacking, berry picking, biking, bird watching, boating, camping, canoeing, Christmas tree, climbing, conflict, disturbance, domestic dog, equestrian, escape, falconry, fleeing, firewood, fishing, flight distance, flush distance, hang gliding, harass, helicopter, hiking, horseback, horsemen, human, intrude, intrusion, kayak, motorcycle, motorized, noise, non motorized, OHV, off highway, ORV, off road, picnicking, plane, rafting, rowing, recreation, riding, sailing, skiing, snowmobile, stress, trail, vehicle, and water sport. References were also selected from the unpublished personal bibliographies of members of The Wildlife Society and other biologists.

Reprints of publications were ordered, and those obtained were available to the volunteer members of the MCTWS Committee on the Effects of Recreation on Wildlife for review. Committee members reviewed the available literature and selected the most relevant references for use in this document (Joslin and Youmans 1999) that identifies issues, impacts, and research needs and provides guidelines for managers. Committee members contributed substantially to the bibliography by annotating and identifying key words in various papers and by adding and selecting entries. The bibliography is partially annotated; committee members annotated as many of the papers as their time allowed, concentrating on the most relevant papers and those without an author's abstract or summary. The bibliography also includes many of the authors' abstracts or summaries as well as annotations from other bibliographies. Copies of all papers accumulated during this project are held in repository at the Montana State Library in Helena for public use.

MAINTENANCE OF BIBLIOGRAPHY

MCTWS recognizes the importance of updating this bibliography and is addressing the logistics and funding requirements of maintaining the system. An agreement is currently in place with the USFS Rocky Mountain Station to request follow-up literature searches for an hourly fee. It is recommended that an annual literature search be conducted by the Technical Information Specialist at the USFS Rocky Mountain Research Station Library-Ogden Center to identify new entries for the bibliography. Users of the bibliography are encouraged to send additional references to the acting coordinator of the bibliography (specified on the web site). Wildlife, fisheries, botany, limnology, hydrology, and other natural resource professionals and students interested in annotating papers for the bibliography are also encouraged to contact the bibliography coordinator. Those interested in updating this report

(Joslin and Youmans 1999) may contact the Committee on the Effects of Recreation on Wildlife (specified on the web site). The committee will oversee periodic updates of the online report. The MCTWS will strive to keep this bibliography current so that it may continue to be a valuable source of information that promotes responsible management of recreation in wildlife habitat. Cooperation and support from natural resource agencies and organizations will be gratefully accepted.

Table 10.1. Online and CD-ROM reference databases searched for the bibliography for, "The Effects of Recreation on Rocky Mountain Wildlife." *Access to UM Mansfield Library's online lasernet databases is available to faculty, students, and University of Montana employees. Access to commercial databases used by the Montana State Library is available to Montana State employees and contractors. Access to databases used by U.S. Government department libraries is available to department employees.

ONLINE OR CD-ROM REFERENCE DATABASE	Publisher or online host	*Access provided by
ABSEARCH – North American Wildlife & Natural Resource, Conservation Biology, Zoology, and Wildlife (-1996)	ABSEARCH, Inc.	Montana Dept. Fish, Wildlife & Parks, Region 1
Agricola (1979-1999/June)	National Agriculture Library	BLM Library UM Mansfield Library
Animal Behavior Abstracts (1982-1999/June)	Cambridge Scientific Abstracts (CSA)	UM Mansfield Library
ASFA1: Biological Sciences & Living Resources	CSA	UM Mansfield Library
ASFA3: Aquatic Pollution & Environmental Quality (1990-1999/June)	CSA	UM Mansfield Library
Biological Abstracts (1980-1999/March)	BIOSIS	UM Mansfield Library
Biological Sciences (1982-1999/June)	CSA	UM Mansfield Library
Biology Digest (1989-1999/June)	CSA	UM Mansfield Library
Biosis Previews (1969-1999/May)	BIOSIS	Montana State Library (MSL)
CAB Abstracts (1972-1999/April)	CAB International	MSL
Conference Papers Index (1982-1999/June)	CSA	UM Mansfield Library
Dissertation Abstracts (1980-1999/June)	UMI Company	UM Mansfield Library
Ecology Abstracts (1981-1999/June)	CSA	UM Mansfield Library
Environmental Bibliography (1973-1999/April)	Environmental Studies Institute at Santa Barbara	MSL
Enviroline (1975-1999/March)	International Academy at Santa Barbara	MSL
Inside Conferences (1993-1999/May)	British Lending Library Document Delivery Center	MSL
NTIS (1964-1999/June)	Nat. Tech. Info. Service	UM Mansfield Library
Plant Science (1994-1999/June)	CSA	UM Mansfield Library
Raptor Information System	USGS Biological Resource Division (BRD)	http://www.ris.idbsu.edu
Singleton, P. 1999. Wildlife-Roadway Interactions Bibliography	USFS Pacific Northwest Research Station	http://www.fs.fed.us/pnw/wenlab/research/projects/wildlife
SPORT Discus (1962-1999/April)	Sport Information Resource Center	MSL UM Mansfield Library
Plant Science (1994-1999/June)	CSA	UM Mansfield Library
Pollution Abstracts (1981-1999/June)	CSA	UM Mansfield Library
Fish and Wildlife Reference Service	U.S. Fish and Wildlife Service	http://fa.r9.fws.gov/r9fwrs
USFS, Library Network FS INFO Database (-1997/Dec.)	USFS	Rocky Mountain Res. Station (RMRS) Library-Ogden
Water Resources Abstracts (1967-1999/June)	CSA	UM Mansfield Library
Wildlife Review and Fisheries Review (-1998/Dec.)	National Inf. Services Corporation (NISC)	UM Mansfield Library
Wildlife Worldwide (1935-1999/April)	NISC	RMRS Library-Ogden, USGS BRD Library, and UM Library
Zoological Record	BIOSIS	UM Mansfield Library

LITERATURE CITED

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. University of Wyoming Cooperative Fish and Wildlife Research Unit, Laramie, Wyoming. 141pp.

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 visitor use management planning process by the U.S. Park Service. Biodiversity Legal Foundation, Boulder, Colorado. 132pp.

Caslick, J., and E. Caslick. 1999. New citations on winter recreation effects on wildlife. Appendix I *in* S. T. Olliff, K. Legg, and B. Kaeding, editors. The effects of winter recreation on wildlife: a literature review an assessment. A report from the Greater Yellowstone Coordinating Committee Wildlife Working Group.

Colorado State Parks. 1998. Trails and Wildlife Bibliography. Draft - second version. Colorado State Parks, Denver, Colorado. 114pp.

Joslin, G., and H. Youmans, coordinators. 1999. Effects of recreation on Rocky Mountain wildlife: A Review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of the Wildlife Society.

Singleton, P. 1999. Wildlife-roadway interactions bibliography. U.S. Forest Service Wenatchee Forestry Sciences Lab, Wenatchee, Washington. http://www.fs.fed.us/pnw/wenlab/research/projects/wildlife

U.S. Fish and Wildlife Service. 1995. Wildlife impacts of secondary uses on national wildlife refuges: an electronic annotated bibliography. Division of Refuges, U.S. Fish and Wildlife Service.

Williams, M., and A. Lester. 1996. Annotated bibliography of OHV and other recreational impacts to wildlife. U.S. Forest Service Pacific Southwest Region, Eldorado National Forest, Georgetown Ranger District. 10pp.

York, D. 1994. Recreational-boating disturbances of natural communities and wildlife: an annotated bibliography. National Biological Survey Biological Report 22. 30pp.

APPENDIX A

POSITION STATEMENTS

EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE
A Review for Montana

www.montanatws.org

MONTANA CHAPTER OF THE WILDLIFE SOCIETY

September 1999

Suggested citation for this appendix

Joslin, G. 1999. Position Statements. Appendix A (4 pp.) *in* G. Joslin and H. Youmans, coordinators. Effects of recreation on Rocky Mountain wildlife: A Review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society. 307pp.

APPENDIX A. POSITION STATEMENTS

A. POSITION STATEMENT OF THE MONTANA CHAPTER OF THE WILDLIFE SOCIETY:

Motorized Recreation in Wildlife Habitat

The Montana Chapter of The Wildlife Society (TWS) is a professional association of biologists active in wildlife research, management, education, and administration. The goal of the Montana Chapter of The Wildlife Society (TWS) is scientific management of Montana_s wildlife resources and their habitats. The principle objectives of the Society are: (1) to develop and promote sound stewardship of wildlife resources and of the environment upon which wildlife and humans depend; (2) to actively participate in programs designed to diminish human-induced environmental degradation; (3) to increase awareness and appreciation of wildlife values; and (4) to seek the highest standards in all activities of the wildlife profession.

While appreciating the popularity of various forms of motorized recreation, members of the Montana Chapter of The Wildlife Society recognize that the potential for adverse impact to wildlife resources will attend extensive expansion of mechanized recreational use of public lands and waterways. In addition to biological and ecological concerns, it is also evident that ethical aspects of mechanized relationships with wildlife need to be addressed. Issues pertaining to wildlife include fair chase concepts associated with hunting, both purposeful and indirect harassment, disruption and habituation of wildlife, as well as issues associated with responsible viewing and appreciation of wildlife.

Substantial advancements in the technology of motorized recreation has rendered most traditional public land travel plans insufficient. Responsible resource management demands that provisions for motorized recreation be carefully planned and implemented to prevent irreplaceable wild land and biological communities from diminishing or becoming irreparably compromised.

Wildlife habitat management responsibilities on public land in Montana rests with the following agencies: U.S. Forest Service, Bureau of Land Management, Bureau of Reclamation, U.S. Fish & Wildlife Service (Refuge System), National Park Service, Montana Department of Natural Resources and Conservation (School Trust Lands), and Montana Department of Fish, Wildlife and Parks (Wildlife Management Areas). The Montana Chapter of TWS urges these agencies, as public land natural resource stewards to:

- comprehensively address travel management on public lands through revision and implementation of travel plans based on full compliance with their respective enabling legislation[1]
- follow impact disclosure and public participation processes defined by the National Environmental Policy Act and the Montana Environmental Policy Act, and
- assure that proposed motorized recreation projects receive full wildlife evaluation and individually comply with all regulations.

Conscientious implementation of applicable regulations will help to assure protection of fully functional wildlife habitat on public lands.

Wildlife management responsibility in Montana resides with the Montana Department of Fish, Wildlife and Parks (MFWP). Motorized recreation programs administered by MFWP include the:

* **Montana Snowmobile Grant Program** (Snowmobile Registration Decal Fees, 23-3-616 M.C.A.; Montana Distributors Gasoline Tax, 60-3-201(b)(5) M.C.A)
* **Montana Motorboat Program** (Motorboat Registration Decal Fees 23-2-516, 23-2-533 M.C.A.; Montana Distributors Gasoline Tax, 60-3-201 M.C.A.)

[1] USFS - National Forest Management Act; BLM - Federal Land Policy and Management Act; Bureau of Reclamation - Public Law 89-72; USFWS - National Wildlife Refuge System Administration Act P.L.89-669 and Refuge Recreation Act P.L.87-714; National Park Service Organic Act of 1916; MDNRC 77-1-203 M.C.A,; MFWP 87-1-201 M.C.A.)

* **Montana Off-Highway Vehicle Program** (OHV Decal Fees, 23-2-804 M.C.A.; Montana Distributors Gasoline Tax, 60-3-201(6)(b))
* **National Recreational Trails Act** (or Symms National Recreation Trails Act of 1991).

The Montana Chapter of The Wildlife Society urges the Montana Fish, Wildlife & Parks Commission, in exerting its budget control and policy-making responsibility over MFWP, to assure that the following concerns are addressed when the motorized recreation program funding sources are utilized:

- fully evaluate wildlife sensitivity and habitat effectiveness as they may be compromised by implementation of motorized recreation projects and programs,
- comprehensively address the ramifications of motorized impacts on biological, ecological, aesthetic and traditional values,
- obtain and evaluate information necessary to make informed decisions about implementation of motorized recreation proposals on public land wildlife habitats.

To this end, the Montana Chapter of The Wildlife Society encourages allocation of funds from the aforementioned programs dedicated to environmental review, research, education, and enforcement. It is recommended that these resources be dedicated as necessary to obtain wildlife information in areas identified as sensitive, or defer motorized recreation projects until the required information becomes available. The objective of these allocations would be to assure that the motorized recreational vehicle Programs administered by MFWP are responsible to and compatible with Montana's natural resources including wildlife, air, water, soils, and vegetation.

The Montana Chapter of The Wildlife Society resolves to convene a committee to address *Motorized Recreation in Wildlife Habitat,* to assist wildlife- and land-management agencies in developing **guidelines** to address habitat and sensitivity needs of wildlife that should be considered in the planning and implementation of motorized access projects.

The committee will monitor the travel-planning efforts and grant programs during the coming year and periodically report to the Executive Board regarding agency progress toward adoption and further development of these recommendations.

The Montana Chapter of The Wildlife Society, in its commitment to preserving our wildlife heritage, pledges to utilize the full extent of our professional expertise when addressing programs that have the potential to compromise what many generations of resource conservationists and managers have protected and passed to our custody.

(Adopted March 5, 1997, Membership of Montana Chapter of The Wildlife Society)

B. POSITION STATEMENT OF THE WILDLIFE SOCIETY: CONSERVING BIOLOGICAL DIVERSITY

Biological diversity is the richness, abundance, and variability of plant and animal species and communities and the ecological processes that link them with one another and with soil, air, and water. Human quality of life and survival depend on the conservation of biological diversity.

Biological diversity varies geographically from microscopic to global scales and varies from seasons to geologic time at each location. Its biological attributes include the structure, function, and composition of genes, individuals, populations, subspecies, species, communities, and biotic provinces. Because of this complexity and variability, the conservation of biological diversity -- protection, restoration, management, and sustainable uses -- must be addressed through objectives for specific attributes at specific places and times. A variety of management actions will be needed to meet the many possible objectives for diversity. No one action will meet all objectives in all places or for all times.

Scientific knowledge is essential in developing effective policies, plans, and actions for conserving biological diversity. Human needs and preferences also must be considered.
The foundation for conserving biological diversity should begin with actions to protect, restore, and sustain the integrity of soil, water, air, and native flora and fauna. Both public and private lands must play complementary roles in stewardship of these basic resources. Beyond basic land stewardship, however, different owners will conserve selected attributes of diversity for their purposes.

The policy of The Wildlife Society for conserving biological diversity is to:

1. Support and promote scientifically sound and socially responsible policies and programs to conserve biological diversity.
2. Encourage formulation of achievable and measurable objectives for desired attributes and uses of biological diversity at specific places and times.
3. Promote public and private initiative and responsibility for conserving biological diversity to further landowner goals or organizational missions. Government natural resource agencies should share responsibility for the management of biological diversity.
4. Support scientific research, management, and monitoring of wildlife as indicators of biological diversity.
5. Extend to the conservation of biological diversity the successful programs of cooperation and coordination used in wildlife protection, management, research, and sustainable uses. For example, cooperative wildlife research, management of migratory birds and mammals, interagency agreements, and conservation partnerships between public and private sectors may be useful models.
6. Seek new sources of funding for the conservation of biological diversity from individuals or groups who will benefit or whose actions diminish those benefits for others.
7. Seek to clarify existing laws and policies to specify the attributes of diversity to which they apply, who is responsible for accomplishing conservation objectives, and what priority those objectives should take relative to other environmental and social goals.
8. Encourage policies that reduce undesired effects of human population growth on conditions and trends in specific attributes of biological diversity.
9. Improve citizen understanding of the benefits of biological diversity to ecosystems and human well-being.

(Adopted October 1992, The Wildlife Society Council)

APPENDIX B

VERTEBRATE SPECIES LISTS

B-1 Montana Natural Heritage Program – Explanation of Ranks and Agency Status Designations

B-2 Vertebrate Species of Montana

B-3 Sensitive Vertebrate Species in Montana – Rankings and Status

Refer to the Montana Natural Heritage Program at **http://nris.state.mt.us/mtnhp**

EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE
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September 1999

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Appendix B-1. Montana Natural Heritage Program

P.O. Box 201800
Helena, Montana 59620-1800
(406) 444-3009
http://nris.state.mt.us/mtnhp

Explanation of Ranks and Agency Status Designations

Global and State Ranks

Taxa are evaluated and ranked by the Heritage Program on the basis of their global (range-wide) status, and their state-wide status. These ranks are used to determine protection and data collection priorities, and are revised as new information becomes available.

A scale of 1 (critically imperiled) to 5 (demonstrably secure) is used for these ranks, and each species is assigned the appropriate combination of global (G) and state (S) ranks.

Example: Merriam's shrew = G5 / S3 (i.e., species is demonstrably secure globally; in Montana is found within a restricted range).

Global and state ranks are assigned according to a standardized procedure used by all Natural Heritage Programs (The Nature Conservancy 1992), and are briefly defined below.

Rank	Definition
G1 S1	Critically imperiled because of extreme rarity (5 or fewer occurrences, or very few remaining individuals), or because of some factor of its biology making it especially vulnerable to extinction.
G2 S2	Imperiled because of rarity (6 to 20 occurrences), or because of other factors demonstrably making it very vulnerable to extinction throughout its range.
G3 S3	Either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factors; in the range of 21 to 100 occurrences.
G4 S4	Apparently secure, though it may be quite rare in parts of its range, especially at the periphery.
G5 S5	Demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery.
GU SU	Possibly in peril, but status uncertain; more information needed.
GH SH	Historically known; may be rediscovered.
GX SX	Believed to be extinct; historical records only, continue search.

Other Global and State Rank Codes

A	Accidental in the state; including species (usually birds or butterflies) recorded very infrequently, hundreds or thousands of miles outside their usual range.
B	A state rank modifier indicating breeding status for a migratory species. Example: S1B,SZN – breeding occurrences for the species are ranked S1 (critically imperiled) in the state, nonbreeding occurrences are not ranked in the state.
E	An exotic established in the state; may be native in nearby regions.
HYB	Element represents a hybrid of species
N	A state rank modifier indicating non-breeding status for a migratory species. Example: S1B,SZN — breeding occurrences for the species are ranked S1 (critically imperiled) in the state, nonbreeding occurrences are not ranked in the state.
P	Indicates the element may potentially occur in the state.
Q	Taxonomic questions or problems involved, more information needed; appended to the global rank.
R	Reported in the state; but lacking documentation which would provide a basis for either accepting or rejecting the report.
T	Rank for subspecific taxon (subspecies, variety, or population); appended to the global rank for the full species.
Z	Ranking not applicable.
#	A modifier to SX or SH; the species has been reintroduced but the population is not yet established.

U. S. Fish And Wildlife Service Endangered Species Act Status

Abbreviations indicate the categories defined in the U.S. Fish and Wildlife Service Notice of Review and indicate the status of a taxon under the federal Endangered Species Act of 1973 (16 U.S.C.A. §1531-1543 (Supp. 1996)).

Note: the categories C2, 3B and 3C are no longer maintained by the U.S. Fish and Wildlife Service (61 FR 7596, Feb. 28, 1996).

Current categories are:

LE listed endangered

LT listed threatened

PE proposed endangered

PT proposed threatened

C candidate: Substantial information exists in U.S. Fish and Wildlife files on biological vulnerability to support proposals to list as threatened or endangered.

NL not listed or no designation (see below)

XN non-essential experimental population

U.S. Forest Service Status

The status of species on Forest Service lands as defined by the U.S. Forest Service manual (2670.22). These taxa are listed as such by the Regional Forester (Northern Region) on National Forests in Montana. Species are listed as:

T/E/P listed as Threatened (LT) or Endangered (LE) under the Endangered Species Act or proposed for listing (P), and known or suspected to occur on national forests.

S sensitive species, subspecies or variety, for which the Regional Forester has determined there is a concern for population viability rangewide or in the region.

Bureau of Land Management Status

The status of species on Bureau of Land Management land is defined by the BLM 6840 manual and designated by the Montana State Office of the BLM
in 1996:

S sensitive species: proven to be imperiled in at least part of its range and documented to occur on BLM lands.

W watch species: either known to be imperiled and suspected to occur on BLM lands, suspected to be imperiled and documented on BLM lands, or needing further study for other reasons.

State Status

These codes give the state legal status of vertebrates as defined in the Nongame and Endangered Species Conservation Act (Mont. Code Ann. §87-5-101 1997)

GA game animal
NG nongame wildlife
GF game fish
P protected species
FB fur bearing animal
U unprotected species
MB migratory bird
UB upland game bird
E endangered
CS closed season
RH restricted harvest

Montana Chapter of The Wildlife Society NOTES

Two genus names are listed for some species. Discussion regarding scientific names continues.

* Species recently reported by field experts as present in Montana, but not yet occurring on Heritage Program list.

/S Species considered "of special interest or concern" by Montana Fish, Wildlife and Parks. This designation includes federally listed and candidate species and other species thought to be rare based on available occurrence and distribution information. In some cases, perceived rarity may be an artifact of limited inventory information.

APPENDIX B-2. Vertebrate Species of Montana

Fish

Scientific Name	Common Name	SC
SC: Y = species of special concern; N = no special status; W = watch		
Cottus bairdi	Mottled sculpin	N
Cottus cognatus	Slimy sculpin	N
Cottus rhotheus	Torrent sculpin	Y
Cottus ricei	Spoonhead sculpin	Y
Myoxocephalus thompsoni	Deepwater sculpin	W
Acipenser transmontanus	White sturgeon	N
Acipenser transmontanus pop 1	White sturgeon (Kootenai River population)	Y
Scaphirhynchus albus	Pallid sturgeon	Y
Scaphirhynchus platorynchus	Shovelnose sturgeon	N
Polyodon spathula	Paddlefish	Y
Lepisosteus platostomus	Shortnose gar	Y
Hiodon alosoides	Goldeye	N
Coregonus artedi	Cisco	N
Coregonus clupeaformis	Lake whitefish	N
Oncorhynchus nerka	Kokanee salmon	N
Oncorhynchus tshawytscha	Chinook salmon	N
Oncorhynchus clarki	Cutthroat trout	N
Oncorhynchus clarki bouvieri	Yellowstone cutthroat trout	Y
Oncorhynchus clarki lewisi	Westslope cutthroat trout	Y
Oncorhynchus mykiss	Rainbow trout	N
Oncorhynchus mykiss gairdneri	Interior redband trout	Y
Oncorhynchus mykiss aguabonita	Golden trout	N
Prosopium coulteri	Pygmy whitefish	N
Prosopium williamsoni	Mountain whitefish	N
Salmo trutta	Brown trout	N
Salvelinus confluentus	Bull trout	Y
Salvelinus fontinalis	Brook trout	N
Salvelinus namaycush	Lake trout	N
Thymallus arcticus	Arctic grayling	N
Thymallus arcticus montanus	Montana arctic grayling	Y
Osmerus mordax	Rainbow smelt	N
Esox lucius	Northern pike	N
Carassius auratus	Goldfish	N
Couesius plumbeus	Lake chub	N
Cyprinus carpio	Common carp	N
Gila atraria	Utah chub	N

Scientific Name	Common Name	SC
SC: Y = species of special concern; N = no special status; W = watch		
Hybognathus argyritis	Western silvery minnow	W
Hybognathus hankinsoni	Brassy minnow	N
Hybognathus placitus	Plains minnow	W
Mylocheilus caurinus	Peamouth	N
Notemigonus crysoleucas	Golden shiner	N
Notropis atherinoides	Emerald shiner	N
Notropis hudsonius	Spottail shiner	N
Notropis stramineus	Sand shiner	N
Phoxinus eos	Northern redbelly dace	N
Phoxinus neogaeus	Finescale dace	N
Phoxinus eos x phoxinus neogaeus	Northern redbelly X finescale dace	Y
Pimephales promelas	Fathead minnow	N
Ptychocheilus oregonensis	Northern squawfish	N
Rhinichthys cataractae	Longnose dace	N
Richardsonius balteatus	Redside shiner	N
Semotilus atromaculatus	Creek chub	N
Hybopsis gelida	Sturgeon chub	Y
Hybopsis meeki	Sicklefin chub	Y
Semotilus margarita	Pearl dace	Y
Hybopsis gracilis	Flathead chub	W
Carpiodes carpio	River carpsucker	N
Catostomus catostomus	Longnose sucker	N
Catostomus commersoni	White sucker	N
Cycleptus elongatus	Blue sucker	Y
Ictiobus bubalus	Smallmouth buffalo	N
Ictiobus cyprinellus	Bigmouth buffalo	N
Moxostoma macrolepidotum	Shorthead redhorse	N
Ictalurus punctatus	Channel catfish	N
Noturus flavus	Stonecat	N
Ictalurus melas	Black bullhead	N
Ictalurus natalis	Yellow bullhead	N
Percopsis omiscomaycus	Trout-perch	Y
Lota lota	Burbot	N
Fundulus zebrinus	Plains killifish	N
Gambusia affinis	Western mosquitofish	N
Poecilia latipinna	Sailfin molly	N
Poecilia mexicana	Shortfin molly	N
Xiphophorus helleri	Green swordtail	N
Xiphophorus variatus	Variable platyfish	N
Culaea inconstans	Brook stickleback	N
Morone chrysops	White bass	N
Ambloplites rupestris	Rock bass	N
Lepomis cyanellus	Green sunfish	N
Lepomis gibbosus	Pumpkinseed	N
Lepomis macrochirus	Bluegill	N

Scientific Name	Common Name	SC
SC: Y = species of special concern; N = no special status; W = watch		
Micropterus dolomieu	Smallmouth bass	N
Micropterus salmoides	Largemouth bass	N
Pomoxis annularis	White crappie	N
Pomoxis nigromaculatus	Black crappie	N
Etheostoma exile	Iowa darter	N
Perca flavescens	Yellow perch	N
Stizostedion canadense	Sauger	N
Stizostedion vitreum	Walleye	N
Aplodinotus grunniens	Freshwater drum	N

Amphibians

Ambystoma macrodactylum	Long-toed salamander	N
Ambystoma tigrinum	Tiger salamander	N
Plethodon idahoensis	Coeur d'Alene salamander	Y
Taricha granulosa	Roughskin newt	N
Dicamptodon aterrimus	Idaho giant salamander	Y
Ascaphus truei	Tailed frog	Y
Bufo boreas	Boreal toad	Y
Bufo canorus	Yosemite toad	N
Bufo cognatus	Great plains toad	W
Bufo hemiophrys	Canadian toad	Y
Bufo woodhousii	Woodhouse's toad	N
**Hyla rigilla*	Pacific tree frog	N
Pseudacris clarkii	Spotted chorus frog	N
Pseudacris maculata	Boreal chorus frog	N
Pseudacris triseriata	Western chorus frog	N
Pseudacris regilla	Pacific chorus frog	N
Spea/Scaphiopus bombifrons	Plains spadefoot	W
Spea/Scaphiopus intermontana	Great basin spadefoot	W
Rana catesbeiana	Bullfrog	N
Rana clamitans	Green frog	N
Rana pipiens	Northern leopard frog	Y
Rana sylvatica	Wood frog	Y
Rana luteiventris	Columbia spotted frog	Y

Reptiles

Chelydra serpentina	Snapping turtle	Y
Chrysemys picta	Painted turtle	N
Trionyx/Apalone spiniferus	Spiny softshell	Y
Elgaria coerulea	Northern alligator lizard	N
Phrynosoma hernandesi	Short-horned lizard	W
Sceloporus graciosus	Sagebrush lizard	W
Eumeces skiltonianus	Western skink	W
Charina bottae	Rubber boa	N

Scientific Name	Common Name	SC
SC: Y = species of special concern; N = no special status; W = watch		
Coluber constrictor	Racer	N
Heterodon nasicus	Western hognose snake	Y
Lampropeltis triangulum	Milk snake	Y
Pituophis catenifer	Gopher snake or bullsnake	N
Thamnophis elegans	Western terrestrial garter snake	N
Thamnophis radix	Plains garter snake	N
Thamnophis sirtalis	Common garter snake	W
Liochlorophis/Oph-eodres vernalis	Smooth green snake	Y
Crotalus viridis	Western rattlesnake	N

Birds

Gavia stellata	Red-throated loon	N
Gavia arctica	Arctic loon	N
Gavia immer	Common loon	Y
Gavia adamsii	Yellow-billed loon	N
Podilymbus podiceps	Pied-billed grebe	N
Podiceps auritus	Horned grebe	N
Podiceps grisegena	Red-necked grebe	N
Podiceps nigricollis	Eared grebe	N
Aechmophorus occidentalis	Western grebe	N
Aechmophorus clarkii	Clark's grebe	Y
Pelecanus erythrorhynchos	American white pelican	Y
Phalacrocorax auritus	Double-crested cormorant	N
Botaurus lentiginosus	American bittern	N
Ixobrychus exilis	Least bittern	N
Ardea herodias	Great blue heron	W
Ardea alba	Great egret	N
Egretta thula	Snowy egret	N
Egretta caerulea	Little blue heron	N
Bubulcus ibis	Cattle egret	N
Butorides virescens	Green heron	N
Nycticorax nycticorax	Black-crowned night-heron	Y
Nyctanassa violacea	Yellow-crowned night-heron	N
Plegadis chihi	White-faced ibis	Y
Mycteria americana	Wood stork	N
Cygnus columbianus	Tundra swan	N
Cygnus buccinator	Trumpeter swan	Y
Cygnus olor	Mute swan	N
Anser albifrons	Greater white-fronted goose	N
Chen caerulescens	Snow goose	N
Chen rossii	Ross' goose	N

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Branta bernicla	Brant	N
Branta canadensis	Canada goose	N
Aix sponsa	Wood duck	N
Anas crecca	Green-winged teal	N
Anas rubripes	American black duck	N
Anas platyrhynchos	Mallard	N
Anas acuta	Northern pintail	N
Anas querquedula	Garganey	N
Anas discors	Blue-winged teal	N
Anas cyanoptera	Cinnamon teal	N
Anas clypeata	Northern shoveler	N
Anas strepera	Gadwall	N
Anas penelope	Eurasian wigeon	N
Anas americana	American wigeon	N
Aythya valisineria	Canvasback	Y
Aythya americana	Redhead	N
Aythya collaris	Ring-necked duck	N
Aythya fuligula	Tufted duck	N
Aythya marila	Greater scaup	N
Aythya affinis	Lesser scaup	N
Somateria mollissima	Common eider	N
Histrionicus histrionicus	Harlequin duck	Y
Clangula hyemalis	Oldsquaw	N
Melanitta nigra	Black scoter	N
Melanitta perspicillata	Surf scoter	N
Melanitta fusca	White-winged scoter	N
Bucephala clangula	Common goldeneye	N
Bucephala islandica	Barrow's goldeneye	N
Bucephala albeola	Bufflehead	N
Lophodytes cucullatus	Hooded merganser	N
Mergus merganser	Common merganser	N
Mergus serrator	Red-breasted merganser	N
Oxyura jamaicensis	Ruddy duck	N
Cathartes aura	Turkey vulture	N
Pandion haliaetus	Osprey	N
Haliaeetus leucocephalus	Bald eagle	Y
Circus cyaneus	Northern harrier	N
Accipiter striatus	Sharp-shinned hawk	N
Accipiter cooperii	Cooper's hawk	N
Accipiter gentilis	Northern goshawk	Y
Buteo lineatus	Red-shouldered hawk	N
Buteo platypterus	Broad-winged hawk	N
Buteo swainsoni	Swainson's gawk	Y
Buteo jamaicensis	Red-tailed hawk	N
Buteo regalis	Ferruginous hawk	Y
Buteo lagopus	Rough-legged hawk	N
Aquila chrysaetos	Golden eagle	N
Falco sparverius	American kestrel	N
Falco columbarius	Merlin	N
Falco peregrinus	Peregrine falcon	Y

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Falco rusticolus	Gyrfalcon	N
Falco mexicanus	Prairie falcon	N
Perdix perdix	Gray partridge	N
Alectoris chukar	Chukar	N
Phasianus colchicus	Ring-necked pheasant	N
Falcipennis canadensis	Spruce grouse	N
Dendragapus obscurus	Blue grouse	N
Lagopus lagopus	Willow ptarmigan	N
Lagopus leucurus	White-tailed ptarmigan	W
Bonasa umbellus	Ruffed grouse	N
Centrocercus urophasianus	Sage grouse	S
Tympanuchus cupido	Greater prairie-chicken	N
Tympanuchus phasianellus	Sharp-tailed grouse	N
Tympanuchus phasianellus columbianus	Columbian sharp-tailed grouse	Y
Meleagris gallopavo	Wild turkey	N
Colinus virginianus	Northern bobwhite	N
Coturnicops noveboracensis	Yellow rail	Y
Rallus limicola	Virginia rail	N
Porzana carolina	Sora	N
Gallinula chloropus	Common moorhen	N
Fulica americana	American coot	N
Grus canadensis	Sandhill crane	N
Grus americana	Whooping crane	Y
Pluvialis squatarola	Black-bellied plover	N
Pluvialis dominica	American golden-plover	N
Pluvialis fulva	Pacific golden-plover	N
Charadrius alexandrinus	Snowy plover	N
Charadrius semipalmatus	Semipalmated plover	N
Charadrius melodus	Piping plover	Y
Charadrius vociferus	Killdeer	N
Charadrius montanus	Mountain plover	Y
Himantopus mexicanus	Black-necked stilt	Y
Recurvirostra americana	American avocet	N
Tringa melanoleuca	Greater yellowlegs	N
Tringa flavipes	Lesser yellowlegs	N
Tringa solitaria	Solitary sandpiper	N
Catoptrophorus semipalmatus	Willet	N
Actitis macularia	Spotted sandpiper	N
Bartramia longicauda	Upland sandpiper	N
Numenius borealis	Eskimo curlew	N
Numenius phaeopus	Whimbrel	N
Numenius americanus	Long-billed curlew	Y
Limosa haemastica	Hudsonian godwit	N

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Limosa fedoa	Marbled godwit	N
Arenaria interpres	Ruddy turnstone	N
Arenaria melanocephala	Black turnstone	N
Calidris canutus	Red knot	N
Calidris alba	Sanderling	N
Calidris pusilla	Semipalmated sandpiper	N
Calidris mauri	Western sandpiper	N
Calidris minutilla	Least sandpiper	N
Calidris fuscicollis	White-rumped sandpiper	N
Calidris bairdii	Baird's sandpiper	N
Calidris melanotos	Pectoral sandpiper	N
Calidris alpina	Dunlin	N
Calidris ferruginea	Curlew sandpiper	N
Calidris himantopus	Stilt sandpiper	N
Tryngites subruficollis	Buff-breasted sandpiper	N
Limnodromus griseus	Short-billed dowitcher	N
Limnodromus scolopaceus	Long-billed dowitcher	N
Gallinago gallinago	Common snipe	N
Scolopax minor	American woodcock	N
Phalaropus tricolor	Wilson's phalarope	N
Phalaropus lobatus	Red-necked phalarope	N
Phalaropus fulicaria	Red phalarope	N
Stercorarius pomarinus	Pomarine jaeger	N
Stercorarius parasiticus	Parasitic jaeger	N
Stercorarius longicaudus	Long-tailed jaeger	N
Larus atricilla	Laughing gull	N
Larus pipixcan	Franklin's gull	Y
Larus philadelphia	Bonaparte's gull	N
Larus canus	Mew gull	N
Larus delawarensis	Ring-billed gull	N
Larus californicus	California gull	N
Larus argentatus	Herring gull	N
Larus thayeri	Thayer's gull	N
Larus glaucoides	Iceland gull	N
Larus glaucescens	Glaucous-winged gull	N
Larus hyperboreus	Glaucous gull	N
Larus marinus	Great black-backed gull	N
Rissa tridactyla	Black-legged kittiwake	N
Xema sabini	Sabine's gull	N
Pagophila eburnea	Ivory gull	N
Sterna caspia	Caspian tern	Y
Sterna hirundo	Common tern	Y
Sterna paradisaea	Arctic tern	N
Sterna forsteri	Forster's tern	Y

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Sterna antillarum athalassos	Interior least tern	Y
Chlidonias niger	Black tern	Y
Brachyramphus perdix	Marbled murrelet	N
Synthliboramphus antiquus	Ancient murrelet	N
Columba livia	Rock dove	N
Columba fasciata	Band-tailed pigeon	N
Zenaida asiatica	White-winged dove	N
Zenaida macroura	Mourning dove	N
Ectopistes migratorius	Passenger pigeon	N
Coccyzus erythropthalmus	Black-billed cuckoo	N
Coccyzus americanus	Yellow-billed cuckoo	Y
Tyto alba	Barn owl	W
Otus flammeolus	Flammulated owl	Y
Otus asio	Eastern screech-owl	W
Otus kennicottii	Western screech-owl	W
Bubo virginianus	Great horned owl	N
Nyctea scandiaca	Snowy owl	N
Surnia ulula	Northern hawk owl	W
Glaucidium gnoma	Northern pygmy-owl	N
Athene cunicularia	Burrowing owl	Y
Strix occidentalis	Spotted owl	N
Strix varia	Barred owl	N
Strix nebulosa	Great gray owl	Y
Asio otus	Long-eared owl	N
Asio flammeus	Short-eared owl	N
Aegolius funereus	Boreal owl	Y
Aegolius acadicus	Northern saw-whet owl	N
Chordeiles minor	Common nighthawk	N
Phalaenoptilus nuttallii	Common poorwill	N
Caprimulgus vociferus	Whip-poor-will	N
Cypseloides niger	Black swift	Y
Chaetura pelagica	Chimney swift	N
Chaetura vauxi	Vaux's swift	N
Aeronautes saxatalis	White-throated swift	N
Archilochus colubris	Ruby-throated hummingbird	N
Archilochus alexandri	Black-chinned hummingbird	N
Calypte anna	Anna's hummingbird	N
Stellula calliope	Calliope hummingbird	N
Selasphorus platycercus	Broad-tailed hummingbird	W
Selasphorus rufus	Rufous hummingbird	N
Ceryle alcyon	Belted kingfisher	N
Melanerpes lewis	Lewis' woodpecker	N
Melanerpes erythrocephalus	Red-headed woodpecker	N

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Melanerpes carolinus	Red-bellied woodpecker	N
Sphyrapicus varius	Yellow-bellied sapsucker	N
Sphyrapicus thyroideus	Williamson's sapsucker	N
Sphyrapicus nuchalis	Red-naped sapsucker	N
Picoides pubescens	Downy woodpecker	N
Picoides villosus	Hairy woodpecker	Y
Picoides albolarvatus	White-headed woodpecker	N
Picoides tridactylus	Three-toed woodpecker	Y
Picoides arcticus	Black-backed woodpecker	Y
Colaptes auratus	Northern flicker	N
Dryocopus pileatus	Pileated woodpecker	Y
Contopus cooperi	Olive-sided flycatcher	N
Contopus sordidulus	Western wood-pewee	N
Contopus virens	Eastern wood-pewee	N
Empidonax alnorum	Alder flycatcher	Y
Empidonax traillii	Willow flycatcher	N
Empidonax minimus	Least flycatcher	N
Empidonax hammondii	Hammond's flycatcher	N
Empidonax oberholseri	Dusky flycatcher	N
Empidonax occidentalis	Cordilleran flycatcher	N
Sayornis phoebe	Eastern phoebe	N
Sayornis saya	Say's phoebe	N
Myiarchus cinerascens	Ash-throated flycatcher	N
Myiarchus crinitus	Great crested flycatcher	N
Tyrannus vociferans	Cassin's kingbird	Y
Tyrannus verticalis	Western kingbird	N
Tyrannus tyrannus	Eastern kingbird	N
Tyrannus forficatus	Scissor-tailed flycatcher	N
Eremophila alpestris	Horned lark	N
Progne subis	Purple martin	N
Tachycineta bicolor	Tree swallow	N
Tachycineta thalassina	Violet-green swallow	N
Stelgidopteryx serripennis	Northern rough-winged swallow	N
Riparia riparia	Bank swallow	N
Petrochelidon pyrrhonota	Cliff swallow	N
Hirundo rustica	Barn swallow	N
Perisoreus canadensis	Gray jay	N
Cyanocitta stelleri	Steller's jay	N
Cyanocitta cristata	Blue jay	N
Gymnorhinus cyanocephalus	Pinyon jay	N

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Nucifraga columbiana	Clark's nutcracker	N
Pica pica	Black-billed magpie	N
Corvus brachyrhynchos	American crow	N
Corvus corax	Common raven	N
Poecile atricapillus	Black-capped chickadee	N
Poecile gambeli	Mountain chickadee	N
Poecile hudsonicus	Boreal chickadee	N
Poecile rufescens	Chestnut-backed chickadee	N
Sitta canadensis	Red-breasted nuthatch	N
Sitta carolinensis	White-breasted nuthatch	N
Sitta pygmaea	Pygmy nuthatch	N
Certhia americana	Brown creeper	N
Salpinctes obsoletus	Rock wren	N
Catherpes mexicanus	Canyon wren	N
Thryomanes bewickii	Bewick's wren	N
Troglodytes aedon	House wren	N
Troglodytes troglodytes	Winter wren	N
Cistothorus platensis	Sedge wren	N
Cistothorus palustris	Marsh wren	N
Cinclus mexicanus	American dipper	N
Regulus satrapa	Golden-crowned kinglet	N
Regulus calendula	Ruby-crowned kinglet	N
Polioptila caerulea	Blue-gray gnatcatcher	Y
Sialia sialis	Eastern bluebird	N
Sialia mexicana	Western bluebird	N
Sialia currucoides	Mountain bluebird	N
Myadestes townsendi	Townsend's solitaire	N
Catharus fuscescens	Veery	N
Catharus minimus	Gray-cheeked thrush	N
Catharus ustulatus	Swainson's thrush	N
Catharus guttatus	Hermit thrush	N
Hylocichla mustelina	Wood thrush	N
Turdus migratorius	American robin	N
Ixoreus naevius	Varied thrush	N
Dumetella carolinensis	Gray catbird	N
Mimus polyglottos	Northern mockingbird	N
Oreoscoptes montanus	Sage thrasher	N
Toxostoma rufum	Brown thrasher	N
Anthus rubescens	American pipit	N
Anthus spragueii	Sprague's pipit	Y
Bombycilla garrulus	Bohemian waxwing	N
Bombycilla cedrorum	Cedar waxwing	N
Phainopepla nitens	Phainopepla	N
Lanius excubitor	Northern shrike	N
Lanius ludovicianus	Loggerhead shrike	Y
Sturnus vulgaris	European starling	N
Vireo bellii	Bell's vireo	N

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Vireo gilvus	Warbling vireo	N
Vireo philadelphicus	Philadelphia vireo	N
Vireo olivaceus	Red-eyed vireo	N
Vireo plumbeus	Plumbeous vireo	
Vireo cassinii	Cassin's vireo	N
Vermivora pinus	Blue-winged warbler	
Vermivora chrysoptera	Golden-winged warbler	N
Vermivora peregrina	Tennessee warbler	W
Vermivora celata	Orange-crowned warbler	N
Vermivora ruficapilla	Nashville warbler	N
Vermivora virginiae	Virginia's warbler	N
Parula americana	Northern parula	N
Dendroica petechia	Yellow warbler	N
Dendroica pensylvanica	Chestnut-sided warbler	N
Dendroica magnolia	Magnolia warbler	N
Dendroica tigrina	Cape May warbler	N
Dendroica caerulescens	Black-throated blue warbler	N
Dendroica coronata	Yellow-rumped warbler	N
Dendroica nigrescens	Black-throated gray warbler	N
Dendroica townsendi	Townsend's warbler	N
Dendroica virens	Black-throated green warbler	N
Dendroica fusca	Blackburnian warbler	N
Dendroica dominica	Yellow-throated warbler	N
Dendroica pinus	Pine warbler	N
Dendroica discolor	Prairie warbler	N
Dendroica palmarum	Palm warbler	N
Dendroica castanea	Bay-breasted warbler	N
Dendroica striata	Blackpoll warbler	N
Mniotilta varia	Black-and-white warbler	W
Setophaga ruticilla	American redstart	N
Protonotaria citrea	Prothonotary warbler	N
Seiurus aurocapillus	Ovenbird	N
Seiurus noveboracensis	Northern waterthrush	N
Oporornis formosus	Kentucky warbler	N
Oporornis agilis	Connecticut warbler	N
Oporornis philadelphia	Mourning warbler	N
Oporornis tolmiei	MacGillivray's warbler	N
Geothlypis trichas	Common yellowthroat	N
Wilsonia pusilla	Wilson's warbler	N
Wilsonia canadensis	Canada warbler	N
Myioborus pictus	Painted redstart	N
Icteria virens	Yellow-breasted chat	N
Piranga rubra	Summer tanager	N

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Piranga olivacea	Scarlet tanager	N
Piranga ludoviciana	Western tanager	N
Cardinalis cardinalis	Northern cardinal	N
Pheucticus ludovicianus	Rose-breasted grosbeak	N
Pheucticus melanocephalus	Black-headed grosbeak	N
Guiraca caerulea	Blue grosbeak	N
Passerina amoena	Lazuli bunting	N
Passerina cyanea	Indigo bunting	N
Passerina ciris	Painted bunting	N
Spiza americana	Dickcissel	Y
Pipilo chlorurus	Green-tailed towhee	N
Pipilo maculatus	Spotted towhee	N
Spizella arborea	American tree sparrow	N
Spizella passerina	Chipping sparrow	N
Spizella pallida	Clay-colored sparrow	N
Spizella breweri	Brewer's sparrow	N
Spizella pusilla	Field sparrow	N
Pooecetes gramineus	Vesper sparrow	N
Chondestes grammacus	Lark sparrow	N
Amphispiza bilineata	Black-throated sparrow	N
Amphispiza belli	Sage sparrow	Y
Calamospiza melanocorys	Lark bunting	N
Passerculus sandwichensis	Savannah sparrow	N
Ammodramus bairdii	Baird's sparrow	Y
Ammodramus savannarum	Grasshopper sparrow	N
Ammodramus leconteii	Le Conte's sparrow	Y
Ammodramus nelsoni	Nelson's sharp-tailed sparrow	Y
Passerella iliaca	Fox sparrow	N
Melospiza melodia	Song sparrow	N
Melospiza lincolnii	Lincoln's sparrow	N
Melospiza georgiana	Swamp sparrow	N
Zonotrichia albicollis	White-throated sparrow	N
Zonotrichia atricapilla	Golden-crowned sparrow	N
Zonotrichia leucophrys	White-crowned sparrow	N
Zonotrichia querula	Harris' sparrow	N
Junco hyemalis	Dark-eyed junco	N
Calcarius mccownii	McCown's longspur	N
Calcarius lapponicus	Lapland longspur	N
Calcarius pictus	Smith's longspur	N
Calcarius ornatus	Chestnut-collared longspur	N
Plectrophenax nivalis	Snow bunting	N
Dolichonyx oryzivorus	Bobolink	N

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Agelaius phoeniceus	Red-winged blackbird	N
Sturnella neglecta	Western meadowlark	N
Xanthocephalus xanthocephalus	Yellow-headed blackbird	N
Euphagus carolinus	Rusty blackbird	N
Euphagus cyanocephalus	Brewer's blackbird	N
Quiscalus quiscula	Common grackle	N
Molothrus ater	Brown-headed cowbird	N
Icterus spurius	Orchard oriole	N
Icterus bullockii	Bullock's oriole	N
Fringilla montifringilla	Brambling	N
Leucosticte atrata	Black rosy-finch	N
Leucosticte tephrocotis	Gray-crowned rosy-finch	N
Pinicola enucleator	Pine grosbeak	N
Carpodacus purpureus	Purple finch	N
Carpodacus cassinii	Cassin's finch	N
Carpodacus mexicanus	House finch	N
Loxia curvirostra	Red crossbill	N
Loxia leucoptera	White-winged crossbill	N
Carduelis flammea	Common redpoll	N
Carduelis hornemanni	Hoary redpoll	N
Carduelis pinus	Pine siskin	N
Carduelis tristis	American goldfinch	N
Coccothraustes vespertinus	Evening grosbeak	N
Passer domesticus	House sparrow	N

Mammals

Sorex cinereus	Masked shrew	N
Sorex preblei	Preble's shrew	Y
Sorex vagrans	Vagrant shrew	N
Sorex monticolus	Dusky or Montane shrew	N
Sorex nanus	Dwarf shrew	Y
Sorex palustris	Water shrew	N
Sorex merriami	Merriam's shrew	Y
Sorex hoyi	Pygmy shrew	N
Sorex haydeni	Hayden's shrew	N
Myotis lucifugus	Little brown myotis	N
Myotis yumanensis	Yuma myotis	W
Myotis evotis	Long-eared myotis	N
Myotis thysanodes	Fringed myotis	Y
Myotis volans	Long-legged myotis	N
Myotis ciliolabrum	Western small-footed myotis	N
Myotis septentrionalis	Northern myotis	Y
Lasionycteris noctivagans	Silver-haired bat	N
Eptesicus fuscus	Big brown bat	N

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Lasiurus borealis	Eastern red bat	N
Lasiurus cinereus	Hoary bat	N
Euderma maculatum	Spotted bat	Y
Corynorhinus townsendii	Townsend's big-eared bat	Y
Antrozous pallidus	Pallid bat	Y
Ochotona princeps	American pika	N
Sylvilagus floridanus	Eastern cottontail	W
Sylvilagus nuttallii	Mountain cottontail	N
Sylvilagus audubonii	Desert cottontail	N
Lepus americanus	Snowshoe hare	N
Lepus townsendii	White-tailed jack rabbit	N
Lepus californicus	Black-tailed jack rabbit	Y
Brachylagus idahoensis	Pygmy rabbit	Y
Tamias minimus	Least chipmunk	N
Tamias amoenus	Yellow-pine chipmunk	N
Tamias ruficaudus	Red-tailed chipmunk	N
Tamias umbrinus	Uinta chipmunk	Y
Marmota monax	Woodchuck	
Marmota flaviventris	Yellow-bellied marmot	N
Marmota caligata	Hoary marmot	N
Spermophilus townsendii	Townsend's ground squirrel	N
Spermophilus richardsonii	Richardson's ground squirrel	N
Spermophilus armatus	Uinta ground squirrel	N
Spermophilus columbianus	Columbian ground squirrel	N
Spermophilus tridecemlineatus	Thirteen-lined ground squirrel	N
Spermophilus franklinii	Franklin's ground squirrel	N
Spermophilus lateralis	Golden-mantled ground squirrel	N
Spermophilus elegans	Wyoming ground squirrel	N
Cynomys ludovicianus	Black-tailed prairie dog	Y
Cynomys leucurus	White-tailed prairie dog	Y
Sciurus carolinensis	Eastern gray squirrel	N
Sciurus niger	Eastern fox squirrel	N
Tamiasciurus hudsonicus	Red squirrel	N
Glaucomys sabrinus	Northern flying squirrel	N
Thomomys talpoides	Northern pocket gopher	N
Thomomys idahoensis	Idaho pocket gopher	N

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Perognathus fasciatus	Olive-backed pocket mouse	N
Perognathus flavescens	Plains pocket mouse	N
Perognathus parvus	Great Basin pocket mouse	Y
Dipodomys ordii	Ord's kangaroo rat	N
Chaetodipus hispidus	Hispid pocket mouse	Y
Castor canadensis	American beaver	N
Peromyscus maniculatus	Deer mouse	N
Peromyscus leucopus	White-footed mouse	N
Onychomys leucogaster	Northern grasshopper mouse	N
Neotoma cinerea	Bushy-tailed woodrat	N
Clethrionomys gapperi	Southern red-backed vole	N
Phenacomys intermedius	Heather vole	N
Microtus pennsylvanicus	Meadow vole	N
Microtus montanus	Montane vole	N
Microtus longicaudus	Long-tailed vole	N
Microtus ochrogaster	Prairie vole	N
Microtus richardsoni	Water vole	N
Lagurus curtatus	Sagebrush vole	N
Ondatra zibethicus	Muskrat	N
Synaptomys borealis	Northern bog lemming	Y
Rattus norvegicus	Norway rat	N
Mus musculus	House mouse	N
Zapus hudsonius	Meadow jumping mouse	Y
Zapus princeps	Western jumping mouse	N
Erethizon dorsatum	Common porcupine	N
Myocastor coypus	Nutria	N
Canis latrans	Coyote	N
Canis lupus	Gray wolf	Y
Vulpes vulpes	Red fox	N
Vulpes velox	Swift fox	Y
Urocyon cinereoargenteus	Common gray fox	N
Ursus americanus	Black bear	N
Ursus arctos	Grizzly or Brown bear	N
Ursus arctos horribilis	Grizzly bear	Y
Procyon lotor	Common raccoon	N
Martes americana	American marten	N
Martes pennanti	Fisher	Y
Mustela erminea	Ermine	N
Mustela nivalis	Least weasel	N
Mustela frenata	Long-tailed weasel	N
Mustela nigripes	Black-footed ferret	Y
Mustela vison	Mink	N
Gulo gulo	Wolverine	Y
Gulo gulo luscus	North American wolverine	Y

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Taxidea taxus	American badger	N
Spilogale putorius	Eastern spotted skunk	Y
Spilogale gracilis	Western spotted skunk	Y
Mephitis mephitis	Striped skunk	N
Lutra canadensis	Northern river otter	N
Felis/Puma concolor	Mountain lion	N
Lynx canadensis pop 1	Lynx (US Lower 48 Population)	Y
Felis rufus	Bobcat	N
Cervus elaphus	Wapiti or Elk	N
Odocoileus hemionus	Mule deer	N
Odocoileus virginianus	White-tailed deer	N
Alces alces	Moose	N
Rangifer tarandus	Caribou	N
Rangifer tarandus caribou	Woodland caribou	N
Antilocapra americana	Pronghorn	N
Bos bison	American bison	N
Oreamnos americanus	Mountain goat	N
Ovis canadensis	Bighorn sheep	N

Appendix B-3. Sensitive Vertebrate Species in Montana – Rankings and Status

Scientific Name	Common Name	Global Rank	State Rank	US FWS ESA Status	USFS Status	BLM Status	State Status
Fish							
Cottus rhotheus	Torrent sculpin	G5	S2		S		NG
Cottus ricei	Spoonhead sculpin	G5	S1				NG/S
Acipenser transmontanus pop 1	White sturgeon (Kootenai River population)	G4T1 Q	S1	LE	S		GFRH/S
Scaphirhynchus albus	Pallid sturgeon	G1G2	S1	LE	E	E	GFRH/S
Polyodon spathula	Paddlefish	G4	S1S2			S	GFRH/S
Lepisosteus platostomus	Shortnose gar	G5	S1			S	NG/S
Oncorhynchus clarki bouvieri	Yellowstone cutthroat trout	G4T2	S2		S	S	GF/S
Oncorhynchus clarki lewisi	Westslope cutthroat trout	G4T3	S3		S	S	GF/S
Oncorhynchus mykiss gairdneri	Interior redband trout	G5T4?	S2		S		GF/S
Salvelinus confluentus	Bull trout (Columbia River Basin population)	G3	S3	LT	S	T	GFRH/S
Thymallus arcticus montanus	Montana arctic grayling (fluvial)	G5T2 Q	S1	C	S		GFRH/S
Phoxinus eos x phoxinus neogaeus	Northern redbelly x finescale dace	HYB	S3			S	NG/S
Hybopsis gelida	Sturgeon chub	G2	S2	C		C	NG/S
Hybopsis meeki	Sicklefin chub	G3	S1	C		C	NG/S
Semotilus margarita	Pearl dace	G5	S2			S	NG/S
Cycleptus elongatus	Blue sucker	G4	S3?			S	NG/S
Percopsis omiscomaycus	Trout-perch	G5	S1				NG/S
Amphibians							
Plethodon idahoensis	Coeur d'Alene salamander	G3	S2		S	S	NG/S
Dicamptodon aterrimus	Idaho giant salamander	G3	SH				NG/S
Bufo boreas	Boreal toad	G4	S3S4		S		NG
Bufo hemiophrys	Canadian toad	G4	S1			S	NG/S
Rana pipiens	Northern leopard frog	G5	S3S4		S		NG/S
Rana luteiventris	Spotted frog	G5				S	NG
Rana sylvatica	Wood frog	G5				S	NG/S
Ascaphus truei	Tailed frog	G4	S4				NG/S
Reptiles							
Chelydra serpentina	Snapping turtle	G5	S3			S	NG
Trionyx/Apolone spiniferus	Spiny softshell	G5	S3			S	NG/S
Heterodon nasicus	Western hognose snake	G5	S3				NG/S
Lampropeltis triangulum	Milk snake	G5	S2				NG/S
Liochlorophis /Opheodrys vernalis	Smooth green snake	G5	S2S3				NG/S

Scientific Name	Common Name	Global Rank	State Rank	US FWS ESA Status	USFS Status	BLM Status	State Status

Birds

Scientific Name	Common Name	Global Rank	State Rank	US FWS ESA Status	USFS Status	BLM Status	State Status
Gavia immer	Common loon	G5	S2B,SZN		S	S	P/S
Aechmophorus clarkii	Clark's grebe	G5	S2S4B,SZN				P
Pelecanus erythrorhynchos	American white pelican	G3	S2B,SZN				P
Nycticorax nycticorax	Black-crowned night-heron	G5	S2S3B,SZN				P
Plegadis chihi	White-faced ibis	G5	S1B,SZN				P/S
Cygnus buccinator	Trumpeter swan	G4	S2B,S2N		S		MB/S
Aythya valisineria	Canvasback					S	MB
Histrionicus histrionicus	Harlequin duck	G4	S2B,SZN		S		MB/S
Haliaeetus leucocephalus	Bald eagle	G4	S3B,S3N	LT	T		P/S
Accipiter gentilis	Northern goshawk	G5	S3S4		S		P/S
Buteo swainsoni	Swainson's hawk					S	P
Buteo regalis	Ferruginous hawk	G4	S3B,SZN				P/S
Falco peregrinus	Peregrine falcon	G4	S1S2B,SZN	NL	S		E
Centrocercus urophasianus	Sage grouse				S		UB
Tympanuchus phasianellus columbianus	Columbian sharp-tailed grouse	G4T3	S1		S		UB/S
Coturnicops noveboracensis	Yellow rail	G4	S1B,SZN				MBCS
Grus americana	Whooping crane	G1	SZN	LE	E		E
Charadrius melodus	Piping plover	G3	S2B,SZN	LT	T		P/S
Charadrius montanus	Mountain plover	G2	S2B,SZN	PT	P		P/S
Himantopus mexicanus	Black-necked stilt	G5	S2B,SZN				P
Numenius americanus	Long-billed curlew					S	
Larus pipixcan	Franklin's gull	G4G5	S3B,SZN				P/S
Sterna caspia	Caspian tern	G5	S2B,SZN				P/S
Sterna hirundo	Common tern	G5	S3B,SZN				P/S
Sterna forsteri	Forster's tern	G5	S2B,SZN				P
Sterna antillarum athalassos	Interior least tern	G4T2Q	S1B,SZN	LE			P/S
Chlidonias niger	Black tern	G4	S3B,SZN				P/S
Coccyzus americanus	Yellow-billed cuckoo	G5	S3B,SZN				P/S
Otus flammeolus	Flammulated owl	G4	S3B,SZN		S	S	P
Athene cunicularia	Burrowing owl	G4	S3B,SZN		S	S	P/S
Strix nebulosa	Great gray owl	G5	S3			S	P/S
Aegolius funereus	Boreal owl	G5	S4			S	P/S
Cypseloides niger	Black swift	G4	S3B,SZN				P/S
Picoides villosus	Hairy woodpecker					S	
Picoides arcticus	Black-backed woodpecker	G5	S3		S	S	P/S
Picoides tridactylus	Three-toed woodpecker					S	P
Dryocopus pileatus	Pileated woodpecker					S	P
Empidonax alnorum	Alder flycatcher	G5	S1B,SZN				P

Scientific Name	Common Name	Global Rank	State Rank	US FWS ESA Status	USFS Status	BLM Status	State Status
Tyrannus vociferans	Cassin's kingbird	G5	S1S3B,SZN				P
Polioptila caerulea	Blue-gray gnatcatcher	G5	S1B,SAN				P
Anthus spraueii	Sprague's pipit				S		P
Lanius ludovicianus	Loggerhead shrike					S	
Spiza americana	Dickcissel	G5	S1S2B,SZN			S	P/S
Amphispiza belli	Sage sparrow					S	
Ammodramus bairdii	Baird's sparrow	G4	S3S4B,SZN				P/S
Ammodramus leconteii	Le Conte's sparrow	G4	S1S2B,SZN			S	P/S
Ammodramus nelsoni	Nelson's sharp-tailed sparrow	G5	S1B,SZN				P

Mammals

Scientific Name	Common Name	Global Rank	State Rank	US FWS ESA Status	USFS Status	BLM Status	State Status
Sorex preblei	Preble's shrew	G4	S3			S	NG/S
Sorex nanus	Dwarf shrew	G4	S3				NG/S
Sorex merriami	Merriam's shrew	G5	S3			S	NG/S
Myotis thysanodes	Fringed myotis	G5	S3				NG/S
Myotis septentrionalis	Northern myotis	G4	S1				NG/S
Euderma maculatum	Spotted bat	G4	S1		S	S	NG/S
Corynorhinus townsendii	Townsend's big-eared bat	G4	S2S3		S	S	NG/S
Antrozous pallidus	Pallid bat	G5	S1		S		NG/S
Lepus californicus	Black-tailed jack rabbit	G5	S2S3				NG/S
Brachylagus idahoensis	Pygmy rabbit	G4	S2S3		S	S	NG/S
Tamias umbrinus	Uinta chipmunk	G5	S3?				NG/S
Cynomys ludovicianus	Black-tailed prairie dog	G4	S3S4		S	S	NG/S
Cynomys leucurus	White-tailed prairie dog	G4	S1		S	S	NG/S
Perognathus parvus	Great Basin pocket mouse	G5	S2S4				NG/S
Chaetodipus hispidus	Hispid pocket mouse	G5	S1				NG/S
Synaptomys borealis	Northern bog lemming	G4	S2		S	S	NG/S
Zapus hudsonius	Meadow jumping mouse	G5	S2S3			S	NG/S
Canis lupus	Gray wolf	G4	S1	LE	T	E	E
Vulpes velox	Swift fox	G3	S1	C		C	FBCS/S
Ursus arctos horribilis	Grizzly bear	G4T3	S1S2	LT	T		GARH/S
Martes pennanti	Fisher	G5	S2		S	S	FBRH/S
Mustela nigripes	Black-footed ferret	G1	SH#	LE	E	E	E
Gulo gulo luscus	North American wolverine	G5T4	S2			S	FBRH/S
Spilogale putorius	Eastern spotted skunk					S	U
Spilogale gracilis	Western spotted skunk						U/S
Lynx canadensis pop 1	Lynx	G5T?Q	S2	PT	S	S	FBRH/S

APPENDIX C

PROJECT PLANNING

EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE
A Review for Montana

www.montanatws.org

MONTANA CHAPTER OF THE WILDLIFE SOCIETY

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APPENDIX C. PROJECT PLANNING

1. **Steps in the planning/environmental analysis process: a checklist**
2. **Sources of information for project planning/environmental analysis**
3. **Overview of potential effects: a checklist**
4. **Planning/environmental analysis: check lists for soil, air, water, vegetation, unique environmental features, and wildlife**
5. **Concepts to be applied to project planning and environmental analysis: a glossary**

Many planning and environmental analysis processes conducted for recreational projects are inadequate with respect to consideration of wildlife. Factors that contribute to superficial consideration of wildlife include:

- Recreation has traditionally been assumed to be innocuous with respect to wildlife and other natural resources as well as "nonconsumptive" if it does not involve direct mortality as a result of hunting or other forms of "take."
- Categorical exclusion options under the Montana Environmental Policy Act (MEPA) have been exercised liberally with the result that planning and analysis of projects has been minimal, and the public and other stakeholders are poorly informed.
- The scope of the planning/environmental analysis process is too often defined in site-specific terms that reflect project construction requirements rather than a landscape scale that encompasses the natural resources that are potentially affected and/or the zone of influence that users of the project will have on wildlife and other natural resources.
- Planning is often conducted with a focus on past and current conditions rather than as a future-focused process that makes use of trend information to anticipate and consider future conditions.
- Effects/impacts are often considered only at the level of individual disturbances and their short-term effects on individual animals rather than considering tiered effects at the community and ecosystem levels and analysis of longer-term, synergistic, and cumulative effects.
- Provisions for and logistics of managing and maintaining the project (monitoring, enforcement, and reclamation) as well as designing and implementing appropriate information and education measures have often been overlooked.

Biological information compiled during the course of this project illustrates the need to bolster planning and environmental analysis frameworks that have traditionally been used. This Appendix is intended to help the user achieve a systematic approach to project planning and environmental analysis.

1. STEPS IN THE PLANNING/ENVIRONMENTAL ANALYSIS PROCESS: A CHECK LIST

Following is a list of steps that can be used to guide project planning with the ultimate objective of achieving recreational use that is compatible and sustainable with respect to wildlife values.

STEP 1. What is the impetus for this project? (What is its purpose and who is doing it?)

STEP 2. What does the project consist of? (Has it been adequately defined so that it can be described in relation to potentially affected resource values?)

STEP 3. What is the scope of the project? Project scope (the affected environment) should be defined in terms of the uses and users of the project and spatial parameters (geographic area/landscape) and temporal parameters (seasons, expected lifetime of the project) that encompass resources that are potentially affected.

a) Identify type(s) of activities involved with development and implementation of the project and whether they are likely to be intensive (localized) or/and extensive (dispersed)

b) Identify uses and users of the project
   - Uses for which the project is designed as well as unrelated activities that will make use of the project by virtue of its existence and, thus, become associated uses

- Predicted use levels for all uses, both short-term and long-term, based on experience and trend data (e.g., population growth, tourism)
- Predicted seasons of use (for all intended and associated uses and users of the project)

c) Identify the zone of influence that users will have on the landscape
- Predicted extent of human activities and conduct of users, including mobility, direction of travel, distances traveled, speed/noise, frequency, magnitude and predictability of activities, associated activities (such as the presence of natural features that will serve to attract recreationists, e.g. caves, cultural features, cliffs), and characteristics of interfaces with wildlife/wildlife habitats.

d) Preliminary assessment of whether potential effects can be expected to be largely short-term, long-term, synergistic, and/or cumulative

e) Document all wildlife issues raised by all parties associated with the project (to serve as a reality check for project scope)

STEP 4. Where is the project taking place (Affected Environment)? Is it in a sensitive area for wildlife?

a) Identify wildlife values in the area encompassed by the "zone of influence" as well as wildlife populations resident to or associated with that geographic area during portions of the year
- Occurrence/distribution of potentially affected species/species assemblages/communities
- Habitats or habitat features of particular importance or rarity
- Seasons/life stages of particular importance or sensitivity

b) General evaluation of the affected environment

STEP 5. What are the anticipated effects of this project on wildlife, both short-term (individual encounters between humans and wildlife; short-term effects on individual animals) and long-term (long-term effects on wildlife at the level of individuals, populations, and communities).

a) Direct effects
b) Indirect (secondary) effects
c) Synergistic effects
d) Cumulative effects

STEP 6. Are there reasonable alternatives that would address potential effects to wildlife?

a) Can the objective(s) of the project be accomplished while eliminating effects to wildlife?
b) Can the objective(s) of the project be accomplished while mitigating effects to wildlife by:
- Avoiding the impact or not taking a certain action or part(s) of an action?
- Minimizing impacts by limiting the degree or magnitude of the impact?
- Rectifying the effect by repairing, rehabilitating, or restoring the affected wildlife habitat?
- Reducing or eliminating an effect during the life of the project through preservation and maintenance actions?

STEP 7. Identify stewardship/maintenance responsibilities and appropriate partner entities in planning and implementing those responsibilities.

a) Monitoring (ecological parameters and use levels)
b) Maintenance
c) Restoration/reclamation
d) Enforcement

STEP 8. Identify information and education needs (awareness, appreciation, and ethics) and appropriate entities in planning and implementing information and education efforts

a) Profile the anticipated users of the development in order to identify:
- Public information/education needs (including interpretation needs/opportunities)
- Partners in development, maintenance, and reclamation.
- Promote understanding of ecosystems, their function, their importance to humans, and how users can avoid, correct, minimize, or mitigate impacts.

2. SOURCES OF INFORMATION FOR PROJECT PLANNING / ENVIRONMENTAL ANALYSIS

SPECIES/COMMUNITY OCCURRENCE/DISTRIBUTION

- Natural Resource Information System (NRIS), State Library, Helena
- Montana Natural Heritage Program (MTNHP), State Library, Helena

- Montana Atlas of Terrestrial Vertebrates (Hart et al. 1998)
- Montana GAP Analysis Final Report (Redmond et al. 1998)
- Montana Fish, Wildlife and Parks (MFWP) Regional Offices (Kalispell, Missoula, Bozeman, Great Falls, Billings, Glasgow, Miles City) and Resource Area Offices (Butte, Dillon, Helena, Havre, Lewistown)
- U.S. Forest Service (USFS) Offices (Dillon, Hamilton, Billings, Kalispell, Bozeman, Helena, Libby, Great Falls, Missoula)
- Bureau of Land Management (BLM) Field Offices (Billings, Butte, Dillon, Missoula, Lewistown, Great Falls, Havre, Glasgow, Malta, Miles City)

LEGAL/POLICY STATUS

- Species listed as threatened or endangered (T&E) under the federal Endangered Species Act (ESA) or petitioned for listing: http://www.r6.fws.gov (U.S. Fish and Wildlife Service/USFWS web site)
- Legal status of species in Montana (87-5-101, Montana Codes Annotated)
- Species considered "of Special Concern" by MFWP: fwpdf@montana.edu
- Species on "watch list" maintained by Montana Natural Heritage Program (includes state and global rankings): http://www.nris.state.mt.us/mtnhp/
- Species considered "sensitive" by the USFS: http://www.fs.fed.us/r1
- Species considered "sensitive" by the BLM: http://www.nris.state.mt.us/mtnhp

NATURAL HISTORY

- Montana Chapter of The Wildlife Society (TWS) Bibliography (www.montanatws.org)
- Other library resources (books and journals)
- Monitoring and research data

POTENTIAL EFFECTS

- Montana Chapter TWS Bibliography. www.montanatws.org
- Trails and Wildlife Bibliography, Colorado State Parks – Trails Program
- Planning Trails with Wildlife in Mind: A Handbook for Trail Planners
- Wildlife and Recreationists: Coexistence through Management and Research. Knight, R.L., and K.J. Gutzwiller, editors.
- The Effects of Winter Recreation on Wildlife: A Literature Review and Assessment, draft report. Olliff, S. T., K. Legg and B. Kaeding, editors.
- Impacts of Winter Recreation on Wildlife in Yellowstone National Park: A Literature Review and Recommendations. J. W. Caslick.
- On-going research and upcoming journal articles in various journals

RECREATIONIST RESPONSIBILITIES/CONDUCT

- Providing Positive Wildlife Viewing Experiences: A Practical Handbook (Richie, D.)
- Montana Wildlife Viewing Guide (Fischer, H. and C.)
- A Guide to Ultimate Wildlife Watching (brochure)
- Off-Road! Montana. (MFWP brochure)
- Personal Watercraft: *Ride Responsibly In Montana* (MFWP brochure).
- Responsible Watercraft Use and Montana's Loons (Montana Loon Society brochure)
- Tread Lightly on your National Forests and other Public Lands (USFS brochure)
- Keeping the Wild in Wilderness (USFS brochure)
- The Spirit of Fair Chase…The Wilderness Hunters' Code (USFS brochure)
- Wildlife Viewing on the Rocky Mountain Front (USFS brochure)
- Woodsy Owl Recreation tips (USFS brochure)

HUMAN DIMENSIONS

- Institute for Tourism and Recreation, University of Montana, Missoula. www.forestry.umt.edu/itrr
- Travel Montana, Montana Department of Commerce. http://www.travel.state.mt.us
- Responsive Management Unit, MFWP, Helena.

3. OVERVIEW OF POTENTIAL EFFECTS

Each chapter of this report presents and discusses information about the potential effects of recreation upon a species or species group. Refer to the corresponding chapter for more detail on potential effects listed in the following matrix.

	Sensitive Communities & Habitats	Sensitive Stages	Potential Effects of Recreational Activities	Influence in Communities
AMPHIBIANS & REPTILES (Chapter 2)	Water bodies; wetlands; overwintering sites/hibernacula; riparian areas; communities rich in insects, birds, and small mammals that serve as foraging sites	Breeding and migrating adults; aquatic eggs and larvae; over-wintering adults	Introduction of non-indigenous fish, bullfrogs, weeds or pathogens; use of piscicides; chemical contamination by herbicides, pesticides or nitrogen; changes in vegetation composition and structure; crushing by vehicles; excessive noise (immobilization response/hearing loss, leading to inability to hunt or avoid predators); sedimentation (especially if contaminated by heavy metals); contaminated runoff from roads and facilities; construction of water impoundments; management of impoundments exclusively for waterfowl production; changes in flow regimes, water levels or water temperature; artificial lighting of water bodies (reduces foraging and interrupts breeding); handling/killing by humans, dogs or cats; predation by species concomitant with humans; harvesting/collecting for commerce or consumption; rattlesnake roundups; alteration/destruction of den sites	Tadpoles and salamander larvae are key herbivores and canivores in aquatic communities; amphibians and reptiles efficiently transfer energy through terrestrial food webs
BIRDS (Chapter 3)	Riparian; marshes; snags for cavity nesters; trees and cliffs for raptor nesting; groves used by colony nesters	Courtship/ breeding; nest building; incubating; brood rearing; migration; wintering	Energy expenditure associated with flushing/avoidance flights; alteration or conversion of habitats (including removal of nest/potential nest trees/groves/screening vegetation); disruption of foraging or breeding behavior; interruption of incubation; nest disturbance (resulting in egg mortality, predation, loss of nestlings to exposure or predation, nest abandonment); reduced parental attentiveness to young (mortality associated with exposure, dehydration, starvation, premature exit from nest, predation); disturbance factors that render habitat unsuitable for foraging; disturbance factors that render natural features (cliffs, snags) unsuitable/unavailable for perching or nesting; vehicle collisions; poaching; changes in abundance and availability of prey species; firewood cutting (snag removal); changes in species composition (entry of predators and nest parasites); structures that serve as perches for predators and nest-parasites; crushing of ground-nesting species; entanglement in fishing line; embedded fishing lures; ingestion of lead	Predators; prey; creation of nest structures
SMALL MAMMALS (Chapter 4)	Alpine habitats; bogs; subnivian (under snow) environment; caves and abandoned mine features used as bat hibernacula, roosts, or maternity sites	Winter	Soil impacts (compaction, disturbance); changes in the vegetation community (species richness, abundance, biomass, microclimates); snow compaction (and resulting usability and temperature stress in subnivian spaces); recreational shooting; crushing by vehicles	Herbivores; prey; creation of habitat for other species (prairie dogs, ground squirrels); cultivators of soil (burrowing)
SEMI-AQUATIC MAMMALS (Chapter 5)	Aquatic and riparian habitats; banks and shorelines	Breeding; parturition; post-natal; dispersal	Changes in riparian zone vegetation; alteration of bank/shore structure and stability (for denning), degradation of water quality (turbidity, pollution via garbage, human excrement, combustion by products, fuel leaks); displacement or reduced palatability of prey (tainted fish); reduced hatching success of prey (fish), increased energy expenditure (disturbance, harassment); disturbance of sediments (and release of toxins) caused by turbulence; increased trapping harvest; predation by dogs	Herbivores; predators; keystone species (beaver)

	Sensitive Communities & Habitats	Sensitive Stages	Potential Effects of Recreational Activities	Influence in Communities
UNGULATES (Chapter 6)	Winter/spring ranges; summer forage; fall security cover; mineral licks	Birthing/rearing; summer foraging/fat accumulation; hunting season; winter/early spring	Forced (excessive) energy expenditure (especially during winter); displacement from public to private lands (causing conflicts with landowners); redistribution resulting from use of packed snow trails; use of packed snow trails by predators to access ungulate wintering areas; weed infestation; use of ORVs for hunting antelope; increased hunting harvest, resulting in skewed male: female ratios; reduced productivity; reduced survival of young/recruitment	Herbivore; prey
CARNIVORES (Chapter 7)				
Wolves	Den and rendezvous sites		Increased human-caused mortality (resulting from >road/trail density); incidentally captured in traps/snares; killed during hunting season or predator calling (mistaken identification); poaching; increased energy expenditure as a result of harassment associated with wolf watching, photography or recreational howling; den abandonment; introduction of disease via dogs; genetic pollution (interbreeding with dogs); habituation to humans/human food sources; vehicle collisions	Predation; may use plowed roads/packed snow trails to access ungulate populations wintering in areas otherwise inaccessible by virtue of snow depth (resulting in increased predation or redistribution of ungulate populations); may injure or kill hounds belonging to hound-hunters or dogs with recreationists
Black Bears	Moist forest/shrub habitats (including mast-producing trees and shrubs); avalanche chutes; wet meadows; riparian habitats; whitebark pine; sidehill parks; subalpine ridgetops	Pre-denning (10/15-12/1); denning; post-denning (3/15-5/15)	Increased human-caused mortality (resulting from >road/trail density); increased hunting mortality; poaching; vehicle collisions; habituation to human foods; berry picking, resulting in displacement from berry patches or competition for berries (accentuates berry shortages in years of low abundance)	Herbivores; predators; scavengers; attractants (food rewards) may lead to habituation, which may in turn lead to conflicts with humans
Grizzly Bears	Whitebark pine; avalanche chutes; mast-producing shrub fields; high elevation moth sites; riparian habitats	Pre-denning; denning; post-denning/early spring	Increased human-caused mortality (resulting from >road/trail density); displacement from important habitats (shrub fields, high elevation moth sites, denning areas) resulting from disturbance or avoidance of roads; poaching; attraction to human and livestock food sources; habituation as a result of food rewards; shooting mortality/management removal resulting from conflicts with humans (confrontations, protection of property, mistaken identification); vehicle collisions	Herbivores, predators, attractants (food rewards) may lead to habituation, which may lead to conflicts with humans

	Sensitive Communities & Habitats	Sensitive Stages	Potential Effects of Recreational Activities	Influence in Communities
Marten, Fisher and Wolverine	Subalpine cirques with rock/scree or large boulder talus (wolverine natal denning); forest riparian; large diameter trees with mistletoe growths (resting sites for fishers); late-successional stages of mesic conifer forests with complex structure at ground level, including hollow logs for denning and other downfall that facilitates access to subnivean spaces	Winter (wolverine rely on carrion)	Disruption of foraging; increased trapping mortality (target and incidental catches); den abandonment (wolverine, fisher, lynx); changes in ungulate distribution (availability of carrion for wolverine); entry of competitors (coyotes, bobcats, lions, wolves) on packed snow trails for prey (snowshoe hare or carrion); introduction of disease via dogs (canine and feline distemper, sarcoptic mange)	Predators; prey; scavengers
Mountain Lion and Lynx	Den sites	Rearing young	Increased hunting/trapping mortality (resulting from >road/trail density); incidental capture in traps/snares; entry of competitor predators facilitate on packed snow trails; introduction of disease via dogs; loss of kittens to hounds (direct mortality or separation from mother)	Predators; lynx largely dependent on snowshoe hares
DOMESTIC DOGS (Chapter 8) Dogs in the company of recreationists may be a factor in recreational activities such as hiking, biking, cross-country skiing, snowshoeing, camping, wood gathering and antler gathering			Increase the radius of human disturbance; accentuated wildlife alarm/stress responses (and associated energy expenditure); pursuit/harassment (and associated accidents); displacement/changes in wildlife distribution; predation (nests, injury or death of neonates and adults); damage to burrow systems; transmission of diseases and parasites (canine distemper, parvo virus); disruption of courtship/breeding activity; disruption of foraging; disruption of roosting sites; flushing of ground-nesting birds; interactions with wolves or bears	In addition to detrimental consequences to wildlife, interactions with wolves or bears may result in death or injury of the dog.
WATER/SOIL/ VEGETATION (Chapter 9)	Areas with shallow water table; bogs; meadows; steep slopes		Physical damage to vegetation (injury, deformation of growth form, <seed production, <carbohydrate reserves, death of plants, changes in community composition); introduction/ establishment of weeds and dispersal of weed seeds (via vehicles, other equipment, hay and manure); physical damage to soil (compaction, displacement, <infiltration, increased water run-off, erosion, reduced productivity, land slides); reduced soil temperature resulting from snow compaction (winter kill of plant tissue, soil microbes); delayed spring re-growth as a result of snow compaction; changes in water quality (>sedimentation, road/trail run-off, herbicides, combustion by-products); streambank erosion/failure	Water, soil and vegetation are the basic components of wildlife habitat.

APPENDIX D

REGULATION AND POLICY
INFLUENCING CONSEQUENCES OF RECREATION UPON WILDLIFE

EFFECTS OF RECREATION ON ROCKY MOUNTAIN WILDLIFE
A Review for Montana

www.montanatws.org

MONTANA CHAPTER OF THE WILDLIFE SOCIETY

Written by

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We the people of Montana, grateful to God for the quiet beauty of our state, the grandeur of our mountains, and the vastness of our rolling plains, do ordain and establish this constitution.
~~ Preamble to the Constitution of the State of Montana ~~

PURPOSE

Human activities can impact animals through four primary routes – exploitation, disturbance, habitat modification, and pollution (Knight and Cole 1995). The intent of this effort to compile wildlife literature and legal references is to provide managers with a background of technical information and legal guidance that provides a basis for adequate planning and implementation of recreational projects. A brief step-down format of basic statutes, regulations, and/or policy that may apply to newly proposed projects is provided for the land, wildlife, or recreation manager faced with implementation decisions. If a project is proposed on federal lands, the full complement of regulations from federal, state, and local jurisdictions would be applicable.

BACKGROUND

Recreation, in all its forms, is now recognized as capable of significant impacts to wildlife (Flather and Cordell 1995, Boyle and Samson 1985). In Montana alone, hundreds of statutes, regulations, and policies are relevant to the protection of wildlife and their habitat. In 1997, the Montana Chapter of The Wildlife Society, concerned about minimal evaluation and due process being applied to recreational projects, adopted a position statement regarding *Motorized Recreation in Wildlife Habitat* (Appendix A). The federal Council on Environmental Quality (1979) declared ORV use, "one of the most serious public land use problems that we face."

Technological advances and the growth in motorized recreation pose expansive potential impacts to wildlife. Four important factors came together during the past 20 years to create a mushrooming effect in motorized recreational activity in Montana: (1) Three recreational programs, funded by both state and federal revenue sources, came into existence; (2) width restrictions on "trail" vehicles were removed; (3) federal land travel management regulations in the West have remained liberal in comparison to the rest of the nation; (4) the motorized-recreation industry launched an aggressive promotional campaign to sell motorized recreational vehicles.

The Montana Snowmobile Grant Program was authorized by the 1977 legislature (MFWP 1998), and the Montana State Off-Highway Vehicle (OHV) Program was initiated in 1992 (MFWP 1998). The Recreational Trails Program (originally the Symms National Recreational Trails Act) came into existence in 1991 as a rider attached to federal highway legislation (§ 1301-1303 of the Intermodal Surface Efficiency Act of 1991). Those funds, dedicated to development of recreational opportunity, are expected to generate approximately $1.2 million in 2000 in Montana alone.

Much of the controversy about motorized recreation on national forest lands began in 1990 when the U.S. Forest (USFS) Service amended the width stipulation for motorized vehicles that could travel on forest trails from 40 inches or less (which was intended to "prohibit certain transportation uses and modes of transport, as well as size of vehicles based on width" [36 CFR. Part 261.12]) to the elimination of any width restriction for motor vehicles (final rule published in Federal Register Vol. 55. No. 122, June 25,1990). This change was made without environmental review or public involvement.

Federal land travel-management regulations in the West have been liberal in comparison to the rest of the United States. Initially, travel management mapping employed designation of significant portions of each national forest as "open to all motor vehicles." Planned travel with area designations is slowly replacing the unregulated approach however, consistency between the legal directives in the overriding forest management plans and the more widely distributed travel maps has not always been applied. The result has been confusion and conflict among the public.

Off-highway vehicle registrations have increased 10% per year from 1990 to 1997 according to the Montana Department of Justice, Title and Registration Bureau, and have grown from 7,399 to 16,898 or 128% in just 7 years. The growth of the ORV industry has been substantial, and with that growth, many primitive trails are being widened to accommodate use by ORVs even though an inventory of Montana trail users indicated that motorized users are out numbered 13 to 1 (MFWP 1997c) by non-motorized users. Guidance provided by the USFS Trails Management Handbook (R-1 Supplement, 1991) indicates that the standard for ORV trail-tread width and vegetation clearing ranges from 9 to 11 feet, while hiking trails vary in tread width and clearing from 4 to 6 feet. While any trail provides a conduit through habitat, a Montana State University Extension Service Bulletin (1992) explains that rapid dispersal of weeds is characteristic of motorized routes where "ORVs can quickly spread 2,000 knapweed seeds over a ten mile area," and a 1998 bulletin states, "Protecting and conserving the surface soil are critical to the long-term sustainability of healthy, functioning ecosystems. In one study, runoff was 1.5 times higher and sediment yield was 3 times higher on spotted knapweed-dominated plots than on plots dominated by the native bluebunch wheatgrass. Loss of soil because of noxious weeds may have very serious consequences in the future" (Sheley et al. 1998).

With the lifting of motorized width restrictions on trails, the ability to travel on national forest lands that are "open to all motor vehicles," and the dramatic growth in numbers of OHVs, pioneering of new routes has raised concerns about the potential for negative consequences to wildlife and wildlife habitat.

From a wildlife and habitat perspective these changes are significant. Information from the Columbia River Basin indicates that 87% of the areas with the greatest forest-ecosystem-health problems contain roads; only 7% of the basin's degraded watersheds are found within roadless areas; about 60% of the best aquatic habitats are found in roadless areas or areas with very low road density (Dombeck 1999). U.S. Forest Service Chief Dombeck (1999) indicates that, "The most productive lands were historically along valley bottoms and mainstem rivers, where we built the first roads. If we ever hope to reconnect the tattered fabric of individual watersheds to an entire landscape, we must look to those area… . [with a plan to] … aggressively decommission roads that degrade the environment…."

As Leslie et al. (1996) points out, "Many believe we are at a critical point in the history of humanity. As the human population continues to grow exponentially (Cohen 1995), species are being lost at unprecedented rates (Wilson 1992; Lawton and May 1995) and habitats and entire ecosystems are being altered (Noss and Peters 1995). Unless this trend is stopped, a major proportion of the natural world will disappear forever. Current leaders and managers have a unique place in human history: of the hundreds of thousands of human generations that ever existed, no previous generation has had to respond to the possible destruction of such a large percentage of biological diversity on the planet…. To meet the management challenge, our approach to environmental management must shift from the traditional reactive mode to a proactive, predictive science that anticipates developing crises and prepares scientifically grounded contingency plans."

Agency-sponsored recreational programs have the potential to increase the magnitude and change the nature of recreation. It is this possibility that obligates systematic evaluation through a review process to ensure retention and where necessary, reclamation of natural resources that support wildlife.

PARTIAL LIST OF STATUTES, REGULATIONS, AND EXECUTIVE ORDERS

This list provides a partial index of statutes, regulations, and policy that land, wildlife, and recreation managers may find applicable when evaluating proposed recreational projects and their potential impacts on natural resources of public lands. This list begins with federal statutes that apply to all federal agencies and are administered through individual agency regulations; the table entitled "Federal Laws That Evoke Conservation Actions" identifies federal laws that managers must consider when evaluating recreational projects on federal lands; the list then steps down to unique statutes and regulations administered by selected agencies. The format is the same for Montana law and individual agencies or local jurisdictions. This effort is a work in progress. Statutes, regulations, and policies that are not listed but may pertain to recreation and recreational development projects should be added.

Federal

Policy
Administrative Procedures Act
National Environmental Policy Act (1969)
Recreation
Executive Order 11644 and 11989 Off-Road Vehicles on Public Lands (1972, 1977)
National Trail Systems Act (1968)
Railway and Revitalization and Regulatory Reform Act of 1976
Wild and Scenic Rivers Act (1968)
Wilderness Act of 1964
Soils, Water, Plants
Executive Order 11990, Protection of Wetlands (1977)
Executive Order 11988, Floodplain Management (1977)
Federal Water Pollution Control Act (Clean Water Act) (1977)
Federal Water Project Recreation Act
Noxious Plant Control
Soil and Water Resources Conservation Act of 1977
Wildlife
Bald and Golden Eagle Protection Act of 1940
Endangered Species Act (1973)
Federal Aid to Wildlife Restoration Act (Pittman-Robertson Act) (1939)
Federal Aid to Fisheries Restoration Act (Dingell-Johnson/Wallop-Breaux Act) (1950, 1984)
Fish and Wildlife Conservation Act of 1980 (the Nongame Act)
Fish and Wildlife Coordination Act of 1958
Lacey Act of 1900
Migratory Bird Treaty Act (1918)
Sikes Act Improvement Act of 1977
Wild and Free-Roaming Horses and Burros Act of 1971

U.S. Forest Service
Multiple Use and Sustained Yield Act of 1960
National Forest Management Act (1976)
Forest and Rangeland Renewable Resources Act of 1974

U.S. Bureau of Land Management
Federal Land Policy and Management Act (1976)

U.S. Fish and Wildlife Service
Alaska National Interest Lands Conservation Act
National Wildlife Refuge System Administration Act of 1966
National Wildlife Refuge System Improvement Act of 1997
Refuge Recreation Act of 1962
Refuge Revenue Sharing Act of 1964

National Park Service
Organic Act of 1916
General Authorities Act of 1970
Enabling acts for each NPS unit

U.S. Department of Defense
Environmental Conservation Program (DoD Instruction 5000.13)
Environmental Protection and Enhancement (AR 200-1)
Environmental Effects of Army Action (NEPA) (AR 200-2)
Natural Resources, Land, Forest and Wildlife Management (AR 200-3)
Use of Off-Road Vehicles on DoD Lands (DoD Directive 6050.2)
Department of Defense Instruction 4715.3, Environmental Conservation Program, May 3, 1996, which updates DoD Directive 4700.4, outlines the Department's current natural resource policy, and provides guidance to installations on implementing an ecosystem-based approach to natural resources management. (Taken from U.S. Army, 1997, Guidelines to Prepare Integrated Natural Resources Management Plans for Army Installations and Activities, pp. 36-37).

State of Montana
Montana Administrative Procedures Act (2-4-601 *et seq.,* MCA)
Montana Environmental Policy Act (75-1-101 *et seq.,* MCA)

Department of Natural Resources and Conservation
Lakeshore Protection (75-7-201 through 217, MCA)
Montana Land-Use License or Easement on Navigable Waters
Montana Water Use Act (85 MCA)
Streamside Management Zone Law (77-5-301 through 307, MCA)

Department of Environmental Quality
Montana Major Facility Siting Act (75-20-101 *et seq.,* MCA)
Montana Water Quality Act (75-5-101 *et seq.,* MCA)

Department of Fish, Wildlife & Parks
Montana Stream Protection Act (87-5-501 *et seq.,* MCA)
Non-game and Endangered Species Conservation Act (87-5-101 *et seq.,* MCA)
Recreation Grant Programs
- Off-Highway Vehicle Program (1992) (23-2-801 *et seq.* MCA)
- Snowmobile Program (1977) (23-2-601 *et seq.,* MCA)
- Recreational Trails Program (1991)
- Montana Motorboat Program (1995) (23-2-508 *et seq.,* MCA; 15-16-202 MCA)

Department of Public Health and Human Services
Tourist Campgrounds and Trailer Courts (50-52-101 *et seq.,* MCA)

Local Jurisdictions
Hazardous Substances – Community Right to Know (Rule 40 CFR § 301 *et seq.*)
Montana Floodplain and Floodway Management Act (Floodplain Development Permit. 76-5-401 through 406, MCA) – County
Montana Natural Streambed and Land Preservation Act (310 Permit) – Conservation District
Lakeshore Protection Act - County
Shoreline Protection and Aquatic Land Conservation Ordinance – Flathead Reservation
Confederated Salish and Kootenai Tribes Water Quality Program –Environmental Protection Div.
Recreational vehicle licensing and registration requirements

LEGAL DIRECTIVES WITH A BASIS IN NATURAL RESOURCE CONSERVATION

Public interest in using, conserving, and protecting natural resource values has resulted in a complex body of law that continues to grow in size as new laws are added while old laws are seldom repealed. The result is a large, complex body of law regulating the management of public lands.

Procedural laws at the federal and state levels reflect constitutional guarantees of due process and equal protection and prescribe how natural resource planning and decision-making processes are conducted. The National Environmental Policy Act (NEPA) and the Montana Environmental Policy Act (MEPA) are two of the laws that regulate process. Compliance with procedural laws is important because natural resource decisions allocate important resource values between competing uses, and, as citizens, we want this process to be fair. "No manager of any class of public lands can escape the task of balancing one good use against another and therefore of making difficult choices among conflicting uses… [The primary purpose of public lands management] is use for the common good, often in ways that are not profitable for the private enterprise" (CEQ 1975). In recent years, the scope of conflict over resource allocation has expanded beyond disputes between commercial and conservation interests. Soaring demand for recreational opportunities has created situations where providing public access is no longer compatible with requirements to protect ecological and geological values (Leslie et al. 1996). Consequently, the land manager must integrate recreational requirements along with commercial and agency requirements when planning for biodiversity.

The body of complex law that has developed and is evolving to address ecological concerns is often grounded in the concept of biodiversity, defined as: The variety of living organisms considered at all levels, from genetics through species, to higher taxonomic levels, and including the variety of habitats and ecosystems, and the processes occurring therein (Meffe and Carroll 1994). The Wildlife Society has deliberated the role of wildlife management in the context of maintaining biodiversity across all ecological spectrums, and has adopted a position statement titled "Conserving Biological Diversity" (Appendix A), which in part states, "The foundation for conserving biological diversity should begin with actions to protect, restore, and sustain the integrity of soil, water, air, and native flora and fauna. Both public and private lands must play complementary roles in stewardship of these basic resources."

The *Convention on Biological Diversity* was signed by more than 150 governments at the 1992 Earth Summit in Rio de Janeiro and became effective as international law in December 1993. The goals of the convention include the conservation of biological diversity, the sustainable use of its components, and the fair and equitable distribution of benefits derived from genetic resources (Leslie et al. 1996).

LEGAL REQUIREMENTS OF FEDERAL AGENCIES

Total federal land holdings amount to about 732 million acres, or roughly one-third of the nation's land area (BLM 1985). In terms of acres managed, the top 5 federal land management agencies are: Bureau of Land Management (BLM; 342 million acres), USFS (192 million acres), U.S. Fish and Wildlife Service (USFWS; 92 million acres), National Park Service (NPS; 72 million acres), and Department of Defense (DoD; 25 million acres).

Public land holdings in Montana constitute 36% of the state's 93 million acres, with 28.7% and 8.1% under federal and state jurisdiction, respectively. To some degree, all land-management agencies are obliged to provide for the health of the environment; indeed, the future and well-being of wildlife depend on careful management of public lands.

Statutes, Executive Orders, and regulations for resource management on public lands that all federal land-management agencies must follow, number in the hundreds. Many of these pertain to recreation and the biological conservation of wildlife that may be influenced by recreation. Many of these legal requirements were detailed in Appendix 3 of Leslie et al. (1996), which is the basis of the discussion presented here. This body of natural resource and public-lands law is dynamic. In addition to new statutes and amendments to existing statutes made by Congress, the Executive Branch periodically updates its regulations. The legal environment of natural resource management becomes even more complex when the legal requirements of various state and local governments are considered.

The purpose of this overview is to aid natural resource managers in working with legal counsel to identify and resolve compliance issues in a timely manner. Managers should not try to interpret the statutes, Executive Orders, and regulations on their own. Many of these laws are brief and somewhat vague by design so that the courts can take into account the unique facts associated with each case. The court's decisions become legal precedent that narrow how the law can be interpreted in the future. Consequently, natural resource managers can find themselves in non-compliance if they try to interpret statutes and regulations and do so in a way that differs from earlier court decisions. Always check with legal counsel to ensure that proposed biodiversity plans and activities reflect current law, including the latest court decisions.

Non-compliance can also occur when the natural resource manager is complying with one requirement and inadvertently violates another. For example, a herbicide used to control an exotic weed that is invading a critical terrestrial habitat could drift into a nearby stream and damage critical aquatic habitat. Or, an unidentified archeological site could be damaged by activities to expand a wetland. Therefore, the natural resource manager should take a comprehensive view of public-lands law when integrating biodiversity management within the agency mission.

Besides compliance with procedural laws mentioned before, such as NEPA, there are numerous substantive laws, which address the management and protection of resource values. Some of these laws focus directly on managing specific biological values, such as the *Bald and Golden Eagle Protection Act (16 U.S.C.A. §§668-668d)*, while many environmental laws seek to protect soil, air and water resources from pollution. Other laws seek to manage a geographical resource, for example, the *Coastal Zone Management Act*.

National policy for natural and cultural resources management on federal lands has evolved rapidly during the past 25 years. Lawmakers have focused most of their attention on the larger land holdings managed by the Departments of the Interior and Agriculture. There are several reasons why natural resource managers in other agencies or entities should have some knowledge of these policies and procedural and substantive laws that direct the largest land-management agencies.

It appears that the nation is moving toward a set of general policies and principles for resource management on public lands. For example, in 1960, the USFS was directed to use the principles of multiple use and sustained yield. In the 1970s, the BLM was also directed to follow these principles, and in the 1980s, the Department of Defense adopted the principles of multiple use and sustained yield.

Interagency partnerships are increasingly being employed. The trend toward ecosystem and biodiversity management will increase the need for partnerships, particularly when lands of one agency border holdings of other agencies. Understanding the similarities and differences between the laws of the various departments will facilitate building partnerships.

<u>Policy and Procedural Requirements</u>

National Environmental Policy Act: This act declares as national policy the need to encourage productive and enjoyable harmony between man and his environment; to promote efforts that will prevent damage to the environment and biosphere and stimulate the health and welfare of man; and, to enrich the understanding of ecological systems and natural resources important to the Nation.

This Act also sets forth the requirements and process for preparing and reviewing environmental analysis, including environmental assessments (EAs) and environmental impact statements (EISs). Guidance on identifying what natural resource activities should trigger an EIS is outlined in the *Code of Federal Regulations (40 CFR Chapter V).* For example, §1507.2(a) outlines what a federal agency must do to demonstrate the use of a systematic, interdisciplinary approach that will ensure the integrated use of the natural and social sciences and the environmental and design arts in planning and decision making. Other guidance is provided in Executive Order 11514. However, most of the legal guidelines on what natural resource activities can trigger an EIS are found in the large body of case law that has been developed during the past 25 years.

How NEPA, the regulations in the CFR, and case law come together to define legal requirements can be illustrated by examining "cumulative impacts." can result in a significant action. The NEPA statute requires an EIS for "major federal actions significantly affecting the quality of the human environment." This raises the question of what are actions that have a significant impact. The regulations (40 CFR §§ 1508.7-1508.8) expand on the statute by treating "effects and "impacts" as synonymous, and require the following effects to be considered: ecological, aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. "Cumulative impact" is the impact that results from other incremental impact of the action when added to the past, present, and reasonably foreseeable future actions. A significant cumulative impact can result from individually minor but collectively significant actions that take place over a period of time.

In *Save Yaak Comm v. Block,* 840 F2d 714 (9th Cir. 1988), the courts determined that the various activities involved in timber production are connected and can result in significant foreseeable cumulative impacts. The court held that timber harvests, reconstruction of primary roads, and the building of feeder roads were all connected and foreseeable and must be considered as a whole in determining the need for an EIS. In an earlier case the court held that Federal agencies use illegal piece-mealing or segmentation to avoid EIS requirements by dividing projects into smaller parts that involve less significant environmental effects. *(City of Chicago v. U.S. Nuc. Reg. Com'n* 701 F.2d 632 (C.A. Ill. 1983)).

Managing public lands for biodiversity requires comprehensive, long-term plans that are likely to have significant impacts on a variety of natural resource values. Before acting on these plans, managers are expected to ensure that they are in compliance with NEPA requirements as expanded upon by the regulations and court findings.

Administrative Procedures Act (5 U.S.C., Chapter 5): This Act specifies how federal agencies promulgate and enforce rules and regulations. Public involvement in these processes is required including access to information. Citizens are entitled to due process and equal protection from agencies regulating arbitrarily or capriciously.

Wildlife Resources

Wildlife protection laws reflect the public's evolving view of wildlife from one of simply food sources to one of valuing wildlife for its recreational, scientific, heritage, and aesthetic aspects. Today, the federal government and the states share the management of wildlife resources. The states continue with their traditional role of regulating hunting and fishing, while the federal agencies focus on managing habitat and protecting threatened species. Statutes defining this partnership that impact biodiversity management include:

Lacey Act (16 U.S.C. §§701, 3371-3378 and 18 U.S.C. §§42): This Act forbids interstate commerce in illegally taken animals

Bald and Golden Eagle Protection Act of 1940 (16 U.S.C. §§668-668d): This Act represents an approach to protection that became common in the 1970s. The Act prohibits the taking of eagles without federal permission and provides for civil and criminal penalties.

Fish and Wildlife Coordination Act of 1958 (16 U.S.C. §§ 661-667e): This statute directs federal agencies to ensure that wildlife receive equal consideration with other values in water development projects.

Wild and Free-Roaming Horses and Burros Act of 1971 (16 U.S.C. §§ 1331-1340): This Act protects these animals on the basis of heritage and diversity values because they are "living symbols of historic and pioneering spirit of the West" and "contribute to the diversity of life forms and enrich the lives of the American people." The Act is also significant as it marks the beginning of a more activist Congress with regard to wildlife issues as well as the beginnings of the Endangered Species Act.

Endangered Species Act (ESA), (16 U.S.C. §§ 1531-1543): This law declares that "threatened and endangered plant and animal species are of aesthetic, ecological, educational, historic, and scientific value to the Nation, and requires the protection of these species and their habitat." The Act's purpose is to provide a means to conserve the ecosystems upon which endangered and threatened species depend. This is accomplished when animals or plants are listed under the Act as endangered or threatened. Some consider the ESA to be the most stringent wildlife law ever passed, anywhere. Federal agencies must conserve listed species. Recovery plans are developed and implemented to guide actions to reverse the decline of these species. In 1999 the USFWS reported that there were

1,180 listed species in the United States (478 animals, 702 plants). States may prepare their own lists of species and may have more protective programs than required by the ESA.

Coordination among federal, state, and local agencies, academic researchers, conservation organizations, private individuals, and major land users is perhaps the most essential ingredient for the recovery of listed species (L. Nordstrom, USFWS, personal communication).

The ESA prohibits the taking of listed species by any person. Taking is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect. Special rules for threatened species can exempt some activities from the taking prohibition as long as conservation of the species is the goal of the special rule. Habitat conservation plans can be developed to promote the conservation of a listed species while allowing some incidental taking of the species. Harm includes any action that may damage the species' breeding, feeding, and shelter.

Federal agencies must ensure that their actions do not jeopardize the continued existence of listed species or adversely modify their critical habitat. In planning an action that is likely to adversely affect a listed species, all federal agencies must consult with the USFWS to ensure that the action is not likely to jeopardize the continued existence of the species. If the USFWS finds that a species or habitat is in jeopardy, it will suggest reasonable and prudent alternatives in the form of a "biological opinion." With this process, an agency likely will be able to proceed with its action and have an incidental amount of taking of the species so long as continued existence is not threatened.

Federal Aid to Wildlife Restoration Act (Pittman-Robertson Act) 16 U.S.C. §§ 669-669I) and the *Federal Aid to Fisheries Restoration Act (Dingell-Johnson/Wallop-Breaux Act) 16 U.S.C. §§ 777-777k*: These Acts provide major funding to the states for wildlife and fish planning and management, respectively, including the acquisition, restoration, and maintenance of habitat. The sources of funding for wildlife and fisheries, respectively, are federal excise taxes on arms and ammunition, and on fishing equipment, boats and motors.

Fish and Wildlife Conservation Act of 1980 (the Nongame Act) (16 U.S.C. 2901-2911): This is the first statute to explicitly recognize that non-game species deserve legal protection. The Act provides for financial and technical aid to the states for non-game wildlife.

Sikes Act (126 U.S.C. ′ 670 et seq.): In this Act, Congress requires various federal agencies to cooperate with the USFWS and appropriate state fish and game agencies to undertake wildlife enhancement projects.

Recreation-related Acts

The Wild and Scenic Rivers Act (16 U.S.C. §§ 1241-1251): This Act provides for designation of rivers that have "outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values." By 1991, more than 120 rivers had been designated and these rivers are to be managed by the federal agency having jurisdiction for the adjacent land.

The Wilderness Act of 1964 (16 U.S.C. §§ 1131-1136): This Act "provides for securing for the American people of present and future generations the benefits of an enduring resource of wilderness." Landres and Meyer (1998) indicate that the National Wilderness Preservation System is composed of 624 wilderness areas which are administered by four different agencies, each having "outstanding opportunities for solitude or a primitive and unconfined type of recreation."

The National Trail Systems Act (16 U.S.C. §§ 1241-1251): This system of trails was created for recreational purposes, and the trails are administered by the agency having jurisdiction for the land traversed by the trail. By 1987, more than 31,000 miles of trails were in the system. Trails can be included for historic as well as scenic values.

The Railway Revitalization and Regulatory Reform Act of 1976 provides for the establishment of trails on abandoned railroad rights-of-way.

The Federal Water Project Recreation Act (16 U.S.C. §§ 4601-12 to 4601-21): This is one of several laws requiring recreational values be considered in water projects. The U.S. Army Corps of Engineers has considerable experience in managing recreational use of water projects.

Executive Order 11989, Off-Road Vehicles on Public Lands, provides for closing areas to use by off-road vehicles where soil, wildlife, or other resource values would be or are being adversely affected.

Conservation of Soil, Water and Plant Resources

Federal Water Pollution Control Act (Clean Water Act) (33 U.S.C. 1251-1387): This Act regulates the discharge of pollutants into waterways and regulates the dredging or filling of wetlands.

Executive Order 11990, Protection of Wetlands, requires federal agencies to take action to minimize the destruction, loss, or degradation of wetlands.

Executive Order 11988, Floodplain Management, requires federal agencies to evaluate the effect of their actions on floodplains.

Noxious Plant Control (PL 90-583), provides for the control of noxious plants on federal lands. Such control can be vital in preventing exotic weeds from invading critical habitat. However, care must be taken so that non-target species are not damaged during control measures that often include the use of pesticides, fire, and mechanical treatments.

Soil Conservation (PL 74-461), provides for soil conservation practices on federal lands.

Cultural Resources

In some instances, biodiversity planning and management may be affected by requirements to protect cultural resources, particularly archeological sites. There are many laws regulating cultural resources including the National Historic Preservation Act of 1966, Archeological and Historic Preservation Act of 1974, Archeological Resources Protection Act (ARPA) of 1979, Abandoned Shipwreck Act of 1987, and the Native American Graves Protection and Repatriation Act of 1990. Archeological and historic resources are highly valued by the nation, and violation of some of these laws can result in criminal penalties. Protecting one resource may not justify harming another so the natural resource manager should work closely with the cultural resource manager to avoid such impacts.

SPECIFIC FEDERAL AGENCY LEGAL REQUIREMENTS

In addition to the legal requirements that all federal agencies must follow, there are a number of laws and policies that are specific to individual agencies. The statutes for federal agencies with management authority within the state of Montana are partially listed here.

Bureau of Land Management

Federal Land Policy and Management Act (FLPMA) (43 U.S.C. 1701 to 1784): This Act (1976) set forth policies, procedures and substantive law for land planning and management by the BLM. Key provisions are that these public lands will, for the most part, be retained in federal ownership and will be managed under the principles of multiple use and sustained yield. The Act granted the BLM new authorities and responsibilities, amended or repealed previous legislation, prescribed specific management techniques, and established California Desert Conservation Area.

In addition to broad statutes described above, more specific planning procedures for the BLM are defined in 43 CFR Ch. 11 Subch. A Parts 1600 (10-1-95 edition). Directives specific to ORVs are partially reiterated below for reference and to recommend stringent application of existing regulations as well as application of standardized regulatory language for ORV use applied to all public lands. Such regulation would be in the best interest of wildlife and other natural resource values as well as provide clarity to public land users regarding ORV use throughout Montana.

Off-Road Vehicle directives *(43 CFR § 8340-8344)* for BLM lands, in part, state:

- No person may operate an off-road vehicle on public lands *(43 CFR § 8341.1(f))*: *(4)* In a manner causing or likely to cause significant, undue damage to or disturbance of the soil, wildlife, wildlife habitat, improvements, cultural or vegetative resources, or other authorized uses of the public lands.
- 43 CFR ′ 8341.2 Special rules. (a) …where the authorized officer determines that off-road vehicles are causing or will cause considerable adverse effects upon soil, vegetation, wildlife, wildlife habitat, cultural resources, historical resources, threatened or endangered species, wilderness suitability, other authorized uses, or other resources, the authorized officer shall immediately close the areas affected to the types of vehicle causing the effect until the adverse effects are eliminated and measures implemented to prevent recurrence.
  (b) Each state director is authorized to close portions of the public lands to use by off-road vehicles, except those areas or trails that are suitable and specifically designated as open to such use….

The BLM has specific direction for designation of areas and trails in Subpart 8342 of 43 CFR. It states that the authorized officer shall designate all public lands as either open, limited, or closed to off-road vehicles. All designations shall be based on the protection of the resources of the public lands, the promotion of safety for all users of public lands, and the minimization of conflicts among various uses of the public lands. The following criteria are used to make these designations: (a) Areas and trails shall be located to minimize damage to soil, watershed, vegetation, air, or other resources of the public lands, and to prevent impairment of wilderness suitability. (b) Areas and trails shall be located to minimize harassment of wildlife or significant disruption of wildlife habitats. Special attention will be given to protect endangered or threatened species and their habitats. (c) Areas and trails shall be located to minimize conflicts between off-road vehicle use and other existing or proposed recreational uses of the same or neighboring public lands, and to ensure the compatibility of such uses with existing conditions in populated areas, taking into account noise and other factors. (d) Areas and trails shall not be located in officially designated wilderness areas or primitive areas. Areas and trails shall be located in natural areas only if the authorized officer determines that off-road vehicle use in such locations will not adversely affect their natural, esthetic, scenic, or other values for which such areas are established.

U.S. Forest Service

Multiple-Use Sustained-Yield Act (MUSYA) (16 U.S.C. §§ 528-531): This very short Act passed in 1960 requires the Secretary of Agriculture to manage the national forests for multiple use and sustained yield of a mix of products and services. Multiple use and sustained yield are defined.

In a series of Acts passed in the 1970s, Congress provided more guidance on how natural resource planning and management should be done on the national forests. These Acts include the National Forest Management Act of 1976 (NFMA), the Forest and Rangeland Renewable Resources Planning Act of 1974 (16 U.S.C. §§ 1600 to 1614), the Forest and Rangeland Renewable Resources Research Act of 1978 (16 U.S.C. §§ 1641 to 1647), and the Renewable Resources Extension Act of 1978 (16 U.S.C. §§ 1671 to 1676).

The USFS is bound by federal statutes, regulation and agency policy to conserve biological diversity on national forest system lands. In addition, recent agency philosophy, as stated by Chief Dombeck in *A Natural Resource Agenda for the 21st Century* (1998) and in the 1995 draft Renewable Resources Planning Act program document, have reaffirmed conservation of biodiversity as a key responsibility of the USFS. "The identification of species that are at risk or loss of viability and geographic distribution at rangewide, Regional and planning area scales, and that are not adequately conserved in a 'coarse filter' approach that retains examples of all native plant communities and seral stages, is a critical component of meeting these legal and policy requirements" (Shelly et al. 1996).

In addition to the broad statutes described above for federal agencies, a plethora of policy and regulations exist for managing trails on national forest lands. The most comprehensive review of these laws, regulations, and Executive Orders, as well as standards for development and maintenance of trails are provided in *Everything You Wanted to Know About Trails…*, (Beardsley 1996).

Each national forest is managed under forest-wide standards. For example, in the case of the Lolo National Forest, the forest has been managed since 1986 under a forest-wide standard that prohibits cross-country travel by wheeled vehicles.

National directives specific to motorized vehicle use on national forest lands are partially reiterated below to emphasize that existing regulations clearly provide for responsible management of ORVs. The policy for off-road vehicles is found at FSM 2355.03:

1. Provide a diversity of off-road vehicle recreation opportunities when:
   a. The use is compatible with established land and resource management objectives.
   b. The use is consistent with the capability and suitability of the resources.
   c. The type of off-road vehicle opportunity is an appropriate national forest recreation activity.
   d. There is a demonstrated need.

A summary of the Code of Federal Regulations for off-road vehicle management (36CFR) includes:

- 219.21 "off-road vehicle use shall be planned and implemented to protect land and other resources, promote public safety and minimize conflicts with other uses…. classify area and trails….whether or not off-road vehicle use may be permitted…."
- 261.10 "The following are prohibited: (a) Constructing, placing, or maintaining any kind of road, trail, structure. . . on National Forest system land or facilities without a special-use authorization, contract, or approved operating plan."
- 261.12(c) "Damaging and leaving in a damaged condition any such road, trail or segment thereof."
- 261.13 "Use of Vehicle Off Road. It is prohibited to operate any vehicle off Forest Development, State or County roads: (h) In a manner which damages or unreasonably disturbs the land, wildlife or vegetative resources."
- 261.56 "Use of vehicles off forest development roads. When provided by an order, it is prohibited to possess or use a vehicle off forest development roads."
- 295.2(a) states, "On National Forest System lands, the continuing land management planning process will be used to allow, restrict, or prohibit use by specific vehicle types off roads…. If the analysis indicates that the use of one or more vehicle types off roads will cause considerable adverse effects on the resources or other forest visitors, use of the affected areas and trails by the vehicle types. . . will be restricted until such time as the…effects can be eliminated …." (Exec. Order 11989, 1997).
- 295.2(b) states, "Off-road vehicle management plans shall provide vehicle management direction aimed at resource protection, public safety of all users, minimizing conflicts among users, and provide for diverse use and benefits of the National Forests. Designation of areas and trails shall be in accordance with the following (7-1-96 edition as modified by Exec. Order 11644, 1972):
  (1) Areas and trails shall be located to minimize damage to soil, watershed, vegetation, or other resources of the public lands.
  (2) Areas and trails shall be located to minimize harassment of wildlife or disruption of wildlife habitats.
  (3) Areas and trails shall be located to minimize conflicts between off-road vehicle use and other existing or proposed recreation uses of the same or neighboring public lands, and to ensure the compatibility of such uses with existing conditions in populated areas, taking into account noise and other factors.
  (4) Areas and trails shall not be located in officially designated Wilderness Areas or Primitive Areas."
- 295.5 "Monitoring effects of vehicle use off forest development roads. If monitoring and public input indicate the use…is causing or will cause considerable adverse effects (see 295.2)…the area or trail … will be immediately closed…. Forest Supervisors may delegate immediate closure authority to District Rangers or other forest officers in order to facilitate timely actions to meet these objectives."

A temporary moratorium on road construction in roadless areas was published in the Federal Register in January 1998 (36 CFR Part 212) and the Final Rule was published in February 1999 (36 CFR Part 212). Permanent policy direction regarding road construction in roadless areas is currently under consideration..

U.S. Fish and Wildlife Service

The management of national wildlife refuges (NWRs) by the USFWS requires, among other considerations, maintaining a careful balance between public use and wildlife conservation. The current statutory authority for managing the approximately 92 million acres in the National Wildlife Refuge System within 509 individual units located in all 50 states and the territories of the U.S. includes the *Refuge Recreation Act of 1962 (16 U.S.C.A. §§ 460k-460k-4), Refuge Revenue Sharing Act of 1964 (16 U.S.C.A. § 715s, National Wildlife Refuge System Administration Act (Refuge System Act) (16 U.S.C. §§ 668dd-668ee)*, *Alaska National Interest Lands Conservation Act of 1980 (ANILCA),* and the *National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. §§ 668dd)*.

Purdy et al. (1987), reviewed and evaluated USFWS policy applicable to managing human activity on NWRs. Their study was based on policy for public-use management found in the Refuge Manual (8 RM 1-17) and in further clarifications and guidelines provided within each region by the Regional Director. Their study concludes, "When managed in accordance with principles of sound fish and wildlife management and administration, fishing, hunting, wildlife observation, and environmental education in national wildlife refuges have been and are expected to continue to be generally compatible uses." They cite general provisions regarding vehicles (50 CFR Ch.1, subpart C. § 27.31) and find that, "Travel in or use of any motorized or other vehicles, including those used on air, water, ice, or snow, is prohibited on national wildlife refuges except on designated routes of travel, as … in designated areas posted or delineated on maps by the refuge manager …."

National Park Service

The *National Park Service Organic Act* (16 U.S.C. 1 *et seq.* (1988), August 25, 1916, ch. 408, 39 Stat. 535) created the National Park Service to promote and regulate the use of national parks. The Act states that the fundamental purpose of parks, monuments, and reservations is "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

The NPS administers a wide variety of public lands ranging from the national parks to the national seashores. There are more than 20 classifications or types of NPS units found throughout the national park system. While the various units of NPS fall into different classifications and have specific conservation mandates detailed in their enabling acts, management of these areas must be consistent with the purposes set forth in the Organic Act (16 U.S.C. § 1a-1 *et seq.*). An enabling act exists for each NPS unit that describes the designated area and details the valued resources along with any specific purposes for which the unit was set aside (Bahr and Yarmo 1995).

Department of Defense

The United States military is entrusted with 25 million acres of public lands to enable the training and operations necessary to ensure military readiness (Goodman 1996). Ecosystem management is the basis for management of DoD lands and water. Based on the integration of ecological economic and social factors, "the goal of ecosystem management is to maintain and improve the sustainability and native biological diversity of ecosystems concurrent with human activity, including the military mission" (Appendix 3 in Leslie et al. 1996). A compendium of natural resource directives and management are presented in *Conserving Biodiversity on Military Lands – A Handbook for Natural Resources Managers* (Leslie et al. 1996).

The Secretary of Defense is authorized to "carry out a program of planning for, and the development, maintenance, and coordination of wildlife, fish and game conservation and rehabilitation in each military service in accordance with a cooperative plan mutually agreed upon by the Secretary of Defense, the Secretary of the Interior, and the appropriate State agency designated by the State in which the reservation is located."

DoD Instruction 4715.3, Environmental Conservation Program, May 3, 1996, which updates Directive 4700.4, outlines the Department's current natural resource policy and provides guidance to installations on implementing an ecosystem-based approach to natural resources management. Specific policy goals include: (1) manage responsibly in the public interest with a concern for the inherent value of natural resources; (2) practice the principles of multiple use-sustained yield using scientific methods and an interdisciplinary approach; (3) conserve watersheds and natural landscapes, soils, forests, fish and wildlife, and protected species; (4) provide for public use where appropriate; and, (5) enforcement of laws primarily aimed at protecting natural resources and associated recreational activities.

STATE OF MONTANA

A variety of sources were used provide an overview of selected regulations applicable to recreation within the state of Montana. The list is limited, so an effort should be made to contact the appropriate state agency for guidance relative to planning and implementing recreation projects.

Brief explanations of Montana laws that require environmental permits are provided in *Montana Index to Environmental Permits* (Montana Environmental Quality Council 1998). "The document summarizes portions of Montana law that deal with the use and development of the state's natural resources. It is not, however, a legal document and should not be relied on exclusively to determine legal responsibilities.… Anyone planning an activity should contact the administering agency for detailed information before beginning a project" (MEQC 1998; http://www.deq.state.mt.us).

"The Executive Branch agencies of Montana state government administer programs established by statute (contained in the *Montana Code Annotated*) and rule (contained in the *Administrative Rules of Montana*). The principal agencies involved in the issuance or review of environmental permits are the Departments of Agriculture; Environmental Quality; Livestock; Natural Resources and Conservation; Transportation; Fish, Wildlife and Parks; and Public Service Regulation" (MEQC 1998).

As outlined in the *Montana Environmental Policy Act* (MEPA) and each agency's MEPA Administrative Rules, all agencies of the state must conduct an environmental review when making decisions or planning activities that may have an impact on the environment. In conducting the review, the agencies must utilize a systematic, interdisciplinary approach that will ensure the integrated use of the natural and social sciences and the environmental design arts. Depending on the scope and significance of the project, the agency must prepare either and environmental assessment, a mitigated environmental assessment or an environmental impact statement. The environmental review process applies not only to actions initiated by the agency, but also the issuance of state permits, licenses, certificates or other entitlements for use or permission to act that may impact the environment.

Montana Department of Natural Resources and Conservation

Activities on state-owned lands, including the beds of navigable waterways, generally require permits, leases, or easements from the Montana Department of Natural Resources and Conservation (DNRC) and approval from the Board of Land Commissioners. In addition, Montana Fish, Wildlife and Parks and other state agencies should be contacted for information regarding rules and procedures on lands owned or administered by those agencies.

A recreational use license is required for a person 12 years of age or older for general recreational use of state lands. The license is issued for a 12 month period beginning March 1 of each year and expiring the last day of February the following year (77-1-804, *et seq.,* MCA; ARM 36.25.143 *et seq.*). The DNRC *Guide to Recreational Use of State Trust Lands* states, "Motor vehicle use is restricted to federal, state and dedicated county roads or other roads regularly maintained by the county, or to other roads which have been designated open by DNRC. Off-road travel is prohibited."

A brochure entitled, *Montana Access Guide* (BLM 1998) provides information and frequently asked questions about access to federal and state lands.

Montana Fish, Wildlife and Parks

Hunting, Fishing, Trapping, and Wildlife Protection - Montana Fish, Wildlife and Parks (MFWP) is charged with the regulation of fishing, hunting, trapping, and wildlife protection, and the agency issues all hunting, trapping, and fishing permits and licenses in Montana, with the exception of aerial hunting permits (Montana Department of Livestock) and licenses for outfitters and professional guides (Montana Department of Commerce).

The Fish, Wildlife and Parks Commission establishes hunting and fishing seasons and restricts hunting, trapping, and fishing in certain areas. Commercial regulations and details of hunting, fishing, and trapping licenses and regulations can be obtained from MFWP.

The agency also manages non-game and endangered species within the state. Regulations state that no person may take, possess, transport, export, process, sell, or offer for sale or shipment or receive for shipment any species or subspecies of non-game wildlife deemed by MFWP to be in need of management or listed as endangered by the state or the United States or on the United States list of endangered foreign fish and wildlife. Exceptions are: (1) in emergency (life-threatening) situations; and (2) when necessary to prevent property damage or to protect human health if a permit is first obtained from the Director of MFWP, and where possible, done by or under the supervision of an agent of the department. The Director may also permit the taking of endangered species for special purposes such as scientific research or for propagation in captivity (Nongame and Endangered Species Conservation Act; 87-5-101 *et seq.*, ARM 12.5.201). Appendix B lists the Montana legal status of all vertebrate species that are currently listed as sensitive by the state.

Stream Beds – Stream Banks – Wetlands - Public Projects: Any agency or subdivision of federal, state, county or city government, with the exception of irrigation districts must apply for a Stream Protection Act (also called a 124) permit from the Montana Fish, Wildlife and Parks before beginning a project that may alter the bed or banks of any stream or river in Montana (87-5-501 *et seq.,* MCA).

Under Section 404 of the federal Clean Water Act (33 U.S.C. 1344), a permit is required from the U.S. Army Corps of Engineers for the excavation or placement of any dredged or fill material in United States' rivers, streams, lakes, or jurisdictional wetlands. The U.S. Environmental Protection Agency develops environmental review criteria, reviews projects, and has enforcement authority under the Act (816, 33 U.S.C.A. § 1251 *et seq.*; 33 CFR 209 and 40 Federal Register 31319).

State Parks - Except for administrative purposes, the off-road operation of ORVs is prohibited in all state parks (HB314 Sec.3(2), 1999).

Recreation Grant Programs - Montana Fish, Wildlife and Parks administers the Montana Motorboat Program and 3 grant programs relative to trails through its Parks Division:

- Montana Motorboat Program (Motorboat Registration Decal Fees 23-2-516, 23-2-533 M.C.A.; Montana Distributors Gasoline Tax, 60-3-201 M.C.A.). Montana Fish, Wildlife and Parks registers and administers fees for the this program. Local counties also have jurisdiction to assure compliance. Twenty percent of the boat fee in lieu of tax collected by the county treasurer is used to improve regional boating facilities managed by MFWP. This revenue source sunsets (ends) July 1, 2002 (23-2-518,2 23-2-533, MCA). A motorboat decal fee of $2.50 for motorboats 12 feet in length or greater is charged. Twenty percent of the revenue is used for acquisition and maintenance of marine pump-out equipment and other boat facilities. Eighty percent is used for the enforcement of motorboat regulation statutes (23-2-512, MCA). A portion (0.9%) of the state gasoline dealers' license tax is charged as a motorboat fuel tax. It is used for the creation, improvement, and maintenance of state parks where motorboats are allowed (60-3-201(4), MCA). A brochure entitled, *Montana Boating Laws* (MFWP 1998), provides a summary of Montana boating laws and regulations, along with safety and environmental tips. MFWP administers the Montana Motorboat Program, however, local counties have jurisdictional fee collection responsibilities.

- Montana Snowmobile Grant Program (Snowmobile Registration Decal Fees, 23-3-616(6) M.C.A.; Montana Distributors Gasoline Tax, 60-3-201(b)(5), M.C.A.). Montana's state funded snowmobile program was initiated in 1973 when the Montana legislature, with support from organized Montana snowmobilers, passed a law requiring the registration of snowmobiles used on public lands. The 1977 Montana legislature passed legislation that set aside a percentage of the State Distributor's Gasoline Tax for snowmobile programs. The current funding level (1995) from the gasoline tax is 15/28 of 1%. Both the decal fee and the gasoline tax funds are administered by Montana Fish, Wildlife and Parks. Snowmobile funds are used in a variety of ways. Eighty-two percent of the snowmobile funds go "on the ground" for trail grooming and signing. Administrative costs are expended working with snowmobile clubs and the Montana Snowmobile Association to plan their programs and provide technical assistance. The majority of groomed snowmobile trails in Montana are located on USFS managed lands (85.2%). More than 3,772 miles of trails are now being groomed annually from this program. The MFWP, through the trails program, provides grant money, but the USFS determines if groomed trails are suitable on the their property (MFWP 1997b). A brochure entitled, *Montana Snowmobile Laws* (MFWP no date) outlines Montana Code and Administrative Rules applicable to snowmobiles in Montana. While MFWP administers the Snowmobile Grant Program, local counties have jurisdictional fee collection responsibilities.

- Montana Off-Highway Vehicle Program (OHV Decal Fees, 23-2-804 M.C.A.; Montana Distributors Gasoline Tax, 60-3-201(6)(b)). Montana's state funded OHV program was initiated during the 1989 legislative session when the Montana Legislature passed a law requiring the registration of OHVs used on public lands. The 1991 session of Montana Legislature passed legislation that set aside 1/8 of 1% of the Distributor's Gasoline Tax, and established dealer registration and nonresident permit fees for the OHV program. The gas tax and registration funds are administered by MFWP. The majority of OHV trails in Montana are located on USFS managed lands (MFWP 1997a.). A brochure entitled, *Off-Road Montana* (MFWP no date) provides "a summary of OHV laws, regulations, and tips for responsible off-roading." MFWP administers the Off-Highway Vehicle Program, local counties have jurisdictional fee collection responsibilities.

- Recreational Trails Program (16 USC 1241-1249). The Recreational Trails Program (Previously National Recreational Trains Fund) provides a federal source of revenue for trail maintenance and development, which is derived nationally from earmarked revenue on gasoline. These funds are available for projects on a cost share basis of 80% from Recreational Trails Funds and 20% sponsor funds. Allocation of funds is: 40% diversified use, 30% motorized use, 30% non-motorized use. Revenue directed to Montana during fiscal year (FY) 1999 was $522,896 and is expected to average approximately $652,600 through FY2003. This program is administered by Montana Fish, Wildlife and Parks. The *Transportation Equity Act for the 21st Century* (TEA 21) is the means by which funding is provided to the Recreational Trails Program. A variety of provisions are described, including "Uses Not Permitted. A State may not obligate funds apportioned to carry out this section for … (1) condemnation of any kind of interest in property; (2) construction of any recreational trail on National Forest [or BLM] land for any motorized use unless – (A) the land has been designated for uses other than wilderness by an approved forest [BLM] land and resource management plan or has been released to uses other than wilderness by an Act of Congress; and (B) the construction is otherwise consistent with the management direction in the approved forest [BLM] land and resource management plan; … (4) upgrading, expanding, or otherwise facilitating uses by non-motorized recreational trail users and on which, as of May 1, 1991, motorized use was prohibited or had not occurred" (TEA 21, Sec 1112 (a) 206 (g)(4)).

<u>Montana Department of Public Health and Human Services</u>

Administrative Rules of Montana (ARM) define license requirements for operating trailer courts and campgrounds, work camps, and youth camps. Provisions exist for weed control and avoidance of environmental damage upon abandonment. Validation must be obtained from the local health officer (50-52-101 *et seq.* MCA; ARM 16.10.701 *et seq.*: trailer courts and tourist campgrounds; ARM 16.10.901 *et seq.*: work camps; ARM 16.10.801 *et seq.*: youth camps).

LOCAL JURISDICTIONS – LICENSING/REGISTRATION REQUIREMENTS

<u>Boating</u>

All owners of motorboats and owners of sailboats 12 feet in length or longer must obtain a certificate of ownership (title) and a certificate of number (identifying the boat's registration, decal, hull, and title numbers) from the local county treasurer's office prior to operating the boat in state waters. License decals must be displayed on each side of the forward half of the vessel, 3 inches to the rear of its identifying numbers. Out-of-state boats used in Montana for more than 90 consecutive days must also be registered at the county treasurer's office in the county where the boat will be used most often.

Off-Highway Vehicles

No off-highway vehicle may be operated on public lands, trails, easements, lakes, rivers or stream unless a certificate of ownership and a registration decal have first been obtained from the county treasurer's office. Registration decals must be displayed at a conspicuous place on the vehicle as proof that fees have been paid for the current year (23-2-801 *et seq.*, MCA).

Snowmobiles

Before operating a snowmobile on public lands, trails, easements, lakes, rivers, streams, roadways, or shoulders of roadways, streets, or highways, the owner must obtain a certificate of ownership and registration decal from the local county treasurer's office. The decal must be displayed in a conspicuous place on the cowl of the vehicle. A valid driver's license is required to operate a snowmobile on a public roadway unless the operator has taken an approved snowmobile safety education course and is in the presence and under the supervision of a person who is 18 years of age or older (23-2-601 *et seq.*, MCA).

Counties also participate peripherally in the state trails programs by entering into memorandums of understanding regarding access and maintenance of access to trailheads and routes that cross private lands.

POLICY RECOMMENDATIONS

Regulation and policy should be implemented to protect wildlife and other natural resources when educational measures and requests for voluntary compliance do not produce results within a reasonable time frame. The Montana Chapter of The Wildlife Society recommends that:

- Funds from the National Recreational Trails Program cannot be used to convert non-motorized trails to motorized use (Transportation Equity Act, Sec 1112 (a) 206 (g)(4)). This provision should be strictly enforced.
- When evaluating any recreational project, MEPA and NEPA compliance should be followed and categorical exclusion options should be used conservatively.
- The management of OHV use on all USFS Region 1 and BLM lands should be unified and standardized to the standards now in place on National Wildlife Refuge lands and lands administered by MDNRC, and MFWP (i.e. OHV use off of designated system routes is prohibited).
- There be a review of land and wildlife management plans and land/water allocation designations during environmental assessments and that proposed recreation projects be thoroughly addressed with coordination among resource disciplines.
- Educational programs addressing recreation and wildlife (e.g., brochures, video, school presentations, recreation manager training opportunities) should promote understanding of the function and importance of properly functioning ecosystems and should include information on how to avoid, correct, minimize or mitigate impacts.
- Training should be provided to managers so that they can utilize their skills and all available tools to protect and, where necessary, recover the function of natural systems.
- New regulation and agency policy should be pursued where it is clear that voluntary measures are inadequate or unlikely to succeed.
- Action should be taken without delay where circumstances warrant emergency action in order to preempt natural resource deterioration that is the result of any type of recreational activity.
- The 40-inch width rule for motorized vehicles on USFS lands should be reinstated with designation of specific trails for OHVs where such designations can meet the intent of CFR 295.2b and 295.5.
- Management criteria should be defined for the range of habitats occurring within Montana for which the following activities may occur without resulting in disturbance to wildlife classified as sensitive, threatened, endangered, or special status (Montana Natural Heritage Program–Species of Special Concern, Appendix B) or for degradation to their habitats:
  - Personal water craft – with emphasis on bank erosion, water quality, and aquatic life
  - Water sports, from swimming to jet boats
  - Rock climbing
  - Mountain biking, with emphasis on sensitive soils

  - Hiking/skiing/snowshoeing with emphasis on seasonal wildlife disturbance
  - Horseback riding, specific trail placement with respect to sensitive vegetation and soils and seasonal disturbance to wildlife
  - Motorized recreation (motorcycle, OHV, 4x4, snowmobile) with respect to designation of routes to avoid soils, vegetation, and water degradation, as well as sensitive seasonal use areas for wildlife
  - Aerial activities such as hang gliding, hovercraft, helicopters, fixed-wing aircraft with respect to launching sites, taking into consideration sensitive habitats and seasonal wildlife needs, and define minimum distances from the ground depending on seasonal sensitivity or physiological demands of wildlife species as well as noise factors
- After the above criteria have been defined, voluntary compliance (for 3 years) should be pursued through education and signing with the understanding that more stringent regulatory measures will be sought thereafter if voluntary measures have not been successful.

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To keep every cog and wheel is the first precaution of intelligent tinkering.
~~ Aldo Leopold ~~

SOME FEDERAL LAWS WHICH EVOKE CONSERVATION ACTIONS

American Indian Religious Freedom Act of 1978, as amended [42 USC 1996] [PL 95-341]
anadramous Fish Conservation Act (1965) [16 USC 757]
Antiquities Act of 1906 [16 USC 431] [PL 59-209]
Archaeological and Historic Data Preservation Act of 1974 [16 USC 469]
Archaeological Resources Protection Act of 1979 [16 USC 470] [PL 96-095]
Bald Eagle Protection Act of 1940 [16 USC 668]
Clean Air Act (CAA) (1955) [42 USC 7401]
Clean Water Act (CWA) (1977) [33 USC 1251] [PL 92-500]
Conservation Programs on Military Reservations (Sikes Act) [16 USC 670] [PL 86-797]
Emergency Wetlands Resources Act of 1986 [16 USC 3901]
Endangered Species Act (ESA) (1973) [PL 93-205]
Environmental Protection and Enhancement: Subpart H Historic Preservation [32 CFR § 650]
Erosion Protection Act [33 USC 426]
Exotic Organisms (1977) [EO 11987]
Farmland Protection Policy Act of 1981 [7 USC 4201] [PL 97-098]
Federal Cave Resources Protection Act of 1988
Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended [7 USC 136]
Federal Land Policy and Management Act of 1976 [43 USC 1701]
Federal Noxious Weed Act of 1974, as amended [7 USC 2801]
Fish and Wildlife Conservation Act of 1980 [16 USC 2901] [PL 96-366]
Fish and Wildlife Coordination Act of 1934 [16 USC 661]
Floodplain Management (1977) [EO 11988]
Food, Agricultural, Conservation and Trade Act of 1990 (Pesticide Reporting) [7 USC 136I]
Historic Sites Act of 1935 [16 USC 461] [PL 74-292]
Indian Sacred Sites (1996) [EO 13007]
Intergovernmental Coordination Act (1968) [42 USC 4231] [PL 90-577]
Lacey Act of 1900 [16 USC 701, 702; 31 Stat. 187. 32 Stat. 285)
Migratory Bird Treaty Act (1918) [16 USC 703] [PL 65-186]
Multiple-Use Sustained Yield Act of 1960 [16 USC 528]
National Environmental Policy Act of 1969 (NEPA) [42 USC 4321] [PL 91-190]
National Historic Preservation Act of 1966, as amended [16 USC 470] [PL 89-665]
National Register of Historic Places [36 CFR § 60]
Native American Graves Protection and Repatriation Act of 1990 [25 USC 3001] [PL 101-601]
North American Wetlands Conservation Act [16 USC 4401]
Preservation of American Antiquities [43 CFR § 3]
Protection and Enhancement of the Cultural Environment [EO 11593] (1971)
Protection and Enhancement of Environmental Quality [EO 11514] (1970)
Protection of Archaeological Resources: Uniform Regulations [32 CFR § 229]
Protection of Historic and Cultural Properties [36 CFR § 800]
Protection of Wetlands (1977) [EO 11990]
Recreational Fisheries (1995) [EO 12962]
Rivers and Harbors Act of 1899 [33 USC 401]
Safe Drinking Water Act of 1974, as amended [42 USC 300] [PL 93-523]
Salmon and Steelhead Conservation and Enhancement Act of 1980
The Secretary of Interior's Standards for Historic Preservation Projects[36 CFR § 68]
Soil and Water Resources Conservation Act of 1977 [16 USC 2001]
Taylor Grazing Act (1934) [43 USC 315] [PL 73-482]
Use of Off-Road Vehicles on Public Lands [EO 11644, 11989] (1972, 1977)
Water Resources Planning Act [42 USC 1962]
Watershed Protection and Flood Prevention Act [16 USC 1001] [33 USC 701]
Wild and Scenic Rivers Act of 1968 [16 USC 1271] [PL 90-542]

LITERATURE CITED

Bahr, D., and A. Yarmo. 1995. The Road Ripper's Guide to National Parks. Road Removal Implementation Project. Houghton, MI. 22pp.

Beardsley, W. 1996. Everything You Wanted to Know About Trails…(but couldn't find). 2nd ed. Northern Region, Forest Service, Missoula, MT.

Boyle, S. A., and F. B. Samson. 1985. Effects of nonconsumptive recreation on wildlife: a review. Wildlife Society Bulletin 13:110-116.

Bureau of Land Management (BLM). 1985. Public Land Statistics 1984. U.S. Department of the Interior, Washington, D.C.

Bureau of Land Management. 1998. Montana Access Guide – To Federal and State Lands. Montana State Office, BLM. 33pp.

Council on Environmental Quality. 1979. Off-Road Vehicles on Public Lands.

Council on Environmental Quality. 1975. Sixth Annual Report of the Council on Environmental Quality. Washington, D. C.

Cohen , J. E. 1995. *How Many People Can the Earth Support?* W. W. Norton & Co., Inc., New York.

Dombeck, M. 1998. A gradual unfolding of a national purpose: a natural resource agenda for the 21st century. All forest service employees letter, from the forest service chief, dated March 2, 1998.

Dombeck, M. 1999. It's time to address roads. Inner Voice 11(3):17.

Federal Register. January 23, 1998. Administration of the Forest Development Transportation System: Management Regulations Revision and Temporary Suspension of Road Construction in Roadless Areas; Proposed Rules. Part II, Dept. of Ag., Forest Service, 36 CFR Part 212, pp. 4349-4354.

Flather C. H., and H. K. Cordell. 1995. Outdoor Recreation: Historical and Anticipated Trends. Pages: 3-16 *in* R.L. Knight and K. J. Gutzwiller (eds.), Wildlife and Recreationists, Coexistence through Management and Research. Island Press, Washington D.C. and Covelo, California.

Goodman, S. W. 1996. Foreword to Conserving Biodiversity on Military Lands *in* Leslie, et al.. Conserving Biodiversity on Military Lands – A Handbook for natural Resources Managers. The Department of Defense Biodiversity Initiative. U.S. Department of Defense and The Nature Conservancy.

Knight, R. L., and D. N. Cole. 1995. Wildlife Responses to Recreationists. Pages: 51-69 *in* R.L. Knight and K.J. Gutzwiller (eds.) Wildlife and Recreationists, Coexistence through Management and Research. Island Press, Washington D.C. and Covelo, California.

Landres, P., and S. Meyer. 1998. National Wilderness Preservation System Database: Key Attributes and Trends, 1964 through 1998. U.S.D.A. Forest Service rocky Mountain Research Station. Gen. Tech. Rpt. RMRS-GTR-18. 97pp.

Lawton, J. H., and R. M. May (eds.). 1995. Extinction Rates. Oxford University Press, New York.

Leslie, M., G. K. Meffe, J. L. Hardesty, and D. L. Adams. 1996. Conserving Biodiversity on Military Lands – A Handbook for Natural Resources Managers. The Department of Defense Biodiversity Initiative. U.S. Department of Defense and The Nature Conservancy.

Meffe, G. K. and C. R. Carroll. 1994. *Principles of Conservation Biology.* Sinauer Associates, Inc., Sunderland, MA.

Montana Department of Natural Resources. No date. Guide to recreational use of state trust lands. Brochure.

Montana Environmental Quality Council. 1998. Montana Index of Environmental Permits. Montana State Legislature, Legislative Environmental Policy Office, Environmental Quality Council, Helena, MT. 210pp.

Montana Fish, Wildlife and Parks (MFWP). 1997a. OHV Program Annual Report July 1, 1996 – June 30, 1997. Parks Division. Helena, MT. 14pp.

Montana Fish, Wildlife and Parks. 1997c. Montana resident's opinions and attitudes toward Responsive Management. Montana Fish, Wildlife & Parks.

Montana Fish, Wildlife and Parks. 1997b. Snowmobile Program Annual Report July 1996-June 30, 1997. Parks Division. Helena, MT. 23pp.

Montana Fish, Wildlife and Parks. 1998. Montana Boating Laws. Montana Fish, Wildlife and Parks. Helena, MT 32pp.

Montana Fish, Wildlife and Parks. 1998. 2020 Vision for Montana State Parks, System Plan. Montana Fish, Wildlife and Parks. Helena, MT 196pp.

Montana Fish, Wildlife and Parks. No date. Off-Road Montana – A Summary of OHV Laws, Regulations, and Tips for Responsible Off-Roading. Montana Fish, Wildlife and Parks. Helena, MT 16pp.

Montana Fish, Wildlife and Parks. No date. Montana Snowmobile Laws. Montana Code Title 223, Chapter 2, Section 601 and Administrative Rules of Montana 12.6.601. 20pp.

Montana State University Extension Service Bulletin. 1992. Controlling Knapweed on Montana Rangeland. Circular 311, February 1992.

Noss, R. F., and R. L. Peters. 1995. Endangered Ecosystems. A Status Report on America's Vanishing Habitat and Wildlife. Defenders of Wildlife, Washington, D. C.

Purdy, K.G., G. R. Goff, D. J. Decker, G. A. Pomerantz, and N. A. Connelly. 1987. A Guide to Managing Human Activity on National Wildlife Refuges. Human Dimensions Research Unit, Dept. of Natural Resources, Cornell Univ., Ithaca, NY. USDI Fish and Wildlife Service, Research and Development Office of Information Transfer. 57pp.

Sheley, R. L., B. E. Olson, and C. Hoops. 1998. Impacts of noxious weeds on the ecology and economy of Montana. Montana State University Extension Service Bulletin #152.

Shelly, S. Q. Carver, D. Davis, P. Dolan, D. Dorman, D. Godtel, J. Greenlee, M. Hillis, J. Joy, L. Lake, M. Mantas, J. Mariani, M. Mousseaux, J.Reichel, S. Rinehart, and B. Ruediger. 1996. Species at Risk (Task Group 19). Region One Forest Service.

Wilson, E. O. 1992. The Diversity of Life. Harvard University, Cambridge, MA.

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