Recreation and Trail Impacts on Wildlife Species of Interest in Mount Spokane State Park

Pacific Biodiversity Institute

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Introduction

Recreation is an important component of the mission of Washington State Parks, and provides numerous benefits to individuals, communities, and conservation at large. Outdoor recreational experiences contribute to individual health of body and spirit, foster appreciation of and support for environmental protection by the public, and contribute to local economics. Demand for and participation in outdoor recreation is increasing at a notable rate (Table 1). Not only is the number of recreationists increasing, the type of recreation impacts and spatial extent of area affected are also changing. Remote and fragile, high elevation areas that previously received little use and may have served as refuges for sensitive species, are increasingly accessed. Advances in off-road vehicle (ORV), snowmobiling, and mountain biking technology continue to expand the reach of these activities to more challenging terrain (Ruediger et al. 2000, Havlick 2002). Outdoor recreation is the 2nd leading cause of decline of U.S. threatened and endangered species on public lands (Losos et al. 1995) and 4th leading cause across all ownerships (Czech et al. 2000). As recreational use of public lands continues to grow, there is increasing concern over the trade-offs that may exist between recreation and protection of wildlife (Reed and Merenlender 2008).

Table 1. Projected future trends of recreation use in the United States (adapted from Flather and Cordell 1995).

Projected index by year. Indices based on starting value of "100" for year 1987

	2000	2010	2020	2030	2040
Day hiking	123	144	168	198	229
Bicycling	124	146	170	197	218
Developed camping	120	138	158	178	195
Horseback riding	114	125	135	144	149
Primitive camping	108	115	122	130	134
Off-road vehicle use	104	108	112	118	121
Nature study	99	101	103	107	108

While there is now wide recognition of the impacts on wildlife from extractive uses (e.g. hunting and trapping) and high-impact recreation (e.g. ORV use), there is increasing evidence that even the quieter, non-consumptive forms of recreation (e.g. day-hiking, bird watching) may impact species to a greater extent than previously understood. In a study in northern California, Reed and Merenlender (2008) found that protected areas with dispersed, non-motorized recreation had “a five-fold decline in the density of native carnivores and a substantial shift in community composition from native to nonnative species” over protected areas without recreation.

There is particular concern in mountainous regions, as recreational activities tend to be concentrated in valley bottoms, which also provide important habitat for many species of wildlife (Noss et al. 1996). This is especially true in winter when deep snows concentrate wildlife and humans even more (Weaver et al. 1996).

Wildlife can be affected by recreation in a variety of ways, including direct and indirect mortality, lowered productivity, reduced use of habitat/preferred habitat, and aberrant behavior/stress that in turn results in reduced reproductive or survival rates (Purdy et al. 1987). The type of impact depends on the frequency, intensity, location, timing, predictability, and type of use, as well as the type of animal including its size, group size, sex, age and niche (specialized versus generalized) (Knight and Cole 1995). Many types of impacts are indirect and difficult to measure, such as increased risk of disease from physiological stress, but these may be just as damaging as direct impacts (Cole and Landres 1995).

The purpose of this study is to assess potential impacts of recreation and associated trails on wildlife species of interest at Mt. Spokane State Park, Washington. The scope of the report is narrow, and limited primarily to impacts of trail-based recreational activities at Mt. Spokane State Park, which include snowmobiling, hiking, biking, and horseback riding. Snowmobiling is the only motorized form of trail recreation – ORVs are not allowed. Trails include all paths developed primarily for recreation, and not car or truck traffic. These vary in width from narrow hiking corridors to alpine ski runs. Many forms of recreation use roads and there is a large body of literature on road impacts on wildlife. Road impacts are discussed in the report as related to trails, but otherwise such analysis is beyond the scope of this document. Where information exists, responses to distance from trail, duration of response, and mitigations for species are discussed.

The WA State Parks Department identified 21 wildlife species of special concern at Mt. Spokane State Park for assessment (Table 2). These include game and non-game species from a wide range of taxa. These species use a range of environments including mature/old-growth forests, recent burns, meadows, alpine/subalpine, subnivian tunnels, riparian and aquatic habitats, and others.

Information in this document can be useful for evaluating new recreational projects and informing other trail-related management decisions at Mt. Spokane State Park. Recreational impacts on sensitive species can be minimized through proactive management – providing visitor education, and planning for spatial and/or temporal separation of human activity from wildlife. For most species addressed in this study, effects of recreation/human disturbance are considered secondary or minor concerns compared to impacts of habitat loss and/or degradation. However, for species or individuals that are already stressed from habitat loss or other risk factors, seemingly minor effects from human disturbance can be magnified. It is important, therefore, that recreational disturbance is considered in the context of cumulative impacts.

Table 2. Focal wildlife species of Mt. Spokane State Park.

Species	Scientific Name	WDFW Species of Concern	Federal Status
Carnivores			
Gray wolf	*Canis lupus*	State Endangered	Federal Endangered
Canadian lynx	*Lynx canadensis*	State Threatened	Federal Threatened
Wolverine	*Gulo gulo*	State Candidate	Federal Species of Concern
American marten	*Martes americana*	None	None
Ungulates			
Rocky Mountain elk	*Cervus elaphus*	None	None
White-tailed deer	*Odocoileus virginianus ochrourus*	None	None
Moose	*Alces alces*	None	None
Birds			
Northern goshawk	*Picoides arcticus*	State Candidate	Federal Species of Concern
Boreal owl	*Aegolius funereus richardoni*	State Monitor	None
Pileated woodpecker	*Dryocopus pileatus*	State Candidate	None
Black-backed woodpecker	*Picoides arcticus*	State Candidate	None
Dusky grouse	*Dendragapus obscurus pallidus*	None	None
Brown creeper	*Certhia americana*	None	None
Winter wren	*Troglodytes troglodytes*	None	None
Olive-sided flycatcher	*Contopus cooperi*	None	None
Small mammals			
Pika	*Ochotona princeps*	None	None
Pygmy shrew	*Sorex hoyi*	State Monitor	None
Silver-haired bat	*Lasionycteris noctivagans*	None	None
Hoary bat	*Lasiurus cinereus*	None	None
Other species			
Western toad	*Bufo boreas*	State Candidate	Federal Species of Concern
Compton tortoiseshell butterfly	*Nymphalis vaualbum*	State Monitor	None

Methods

We conducted a literature review on recreation and human disturbance information for each of the 21 focal wildlife species. The Web of Science (a prominent literature and cited reference search tool) was used as a primary source for scientific literature, followed by generic internet searches for other relevant information. We reviewed over 100 papers related to recreation impacts on the focal wildlife species and additional papers for information on general outdoor recreation/recreational trends and issues of conservation concern. Where literature was lacking, we contacted local experts.

Results

Overview of trail and recreation impacts

Although recreation is widely recognized as an increasingly important factor affecting wildlife, the study of such impacts is still in its infancy. For many less studied species, information on recreational impacts is completely lacking. For others, sources consist primarily of anecdotal information in older natural history-oriented studies. Wide-ranging carnivores and ungulates have received the most detailed attention, along with very recent studies addressing recreational impacts on presence, diversity and density for general species groups or habitat types. Even for those species with the greatest information however, data is often lacking on specific thresholds of disturbance (intensity of use, distance thresholds, temporal effects, etc.).

Related to a lack of information on wildlife and human interactions, another confounding factor is the amount of conflicting information for various species. Some species that are described in the literature as relatively tolerant of human disturbance, in other accounts appear to be quite sensitive. Notably more rigorous study is needed for all species to clarify wildlife responses to human recreation.

Lastly, much of the information that does exist, particularly for reclusive, low-density species such as the wolverine, is based on relatively simple assessments such as presence/absence data. Behavioral assessments of easier-studied species (e.g. deer/elk) offer additional information but may still miss critical information on how human disturbance affects wildlife. For example, physiological studies of ungulates show animals exhibiting stress responses that may lower their fitness even when behavior does not reveal a notable impact (Creel et al. 2002). Even less understanding exists however, on how such physiological responses affect individual fitness, demographic rates, and population viability.

These gaps and limitations of the available scientific information on wildlife and recreational impacts are important to the understanding and interpretation of this report. Specifically, it is important to highlight that the many cases of no or limited information should not be confused with an implication of “no effect”. Where no data exists on some impact types, but an effect on a species seems likely given its biology, habitat use, and/or response of similar species, we discuss these as potential effects.

A wide variety of impacts from recreation on the 21 species of interest are identified in the literature. In most cases, these are negative, with only a few positive accounts reported. The primary positive aspect is species using recreational trails for easier travel, particularly winter use of compacted trails created by snowmobiles (Richens and Lavigne 1978 *in* Boyle and Samson 1985). Impacts on species from recreational trails and various types of trail use (e.g. hiking, biking, etc.) are categorized into the following headings:

1. <u>Trapping/poaching</u> – Although trapping is not allowed in Washington State Parks, illegal trapping and hunting are cited as risks associated with trails (particularly snowmobile and ORV trails).

2. <u>Stress/physiological response</u> – Studies of heart rates and fecal glucocorticoid levels have shown stress responses to human activity. Chronic stress can make species susceptible to illness and reduce individual fitness (Sapolsky 1992 *in* Creel et al. 2002).

3. <u>Breeding/rearing disturbance</u> – Species that are considered generally tolerant of human activity may experience higher levels of disturbance at breeding and rearing sites. This may result in reduced attentiveness to young, disruption of feeding patterns, abandonment of nests/dens, and/or cause adults to undertake additional risks to their young by moving them to a new location.

4. <u>Displacement/avoidance</u> – A variety of species often move away from human activity or intentionally avoid associated sites. Sites may be avoided due to the disruption caused by human presence or habitat changes associated with the site (e.g. soil compaction, dryness of soils and vegetation along roadsides and trails). Animals displaced by recreation are less likely to survive and reproduce where habitat is unfamiliar or inferior (Gutzwiller 1995). Displacement or avoidance is by far the most common response of species found in the literature.

5. <u>Disease</u> - Domestic dogs are allowed in Washington State Parks, and though regulations specify that they should be restrained at all times, there are undoubtedly many dog owners who do not abide by this rule. A variety of species are vulnerable to diseases such as rabies, distemper, and parasites transmitted by domestic dogs.

6. <u>Animal collection</u> – Although relatively uncommon, certain species (e.g. goshawk chicks for falconry) are sometimes illegally collected. Trail access can increase vulnerability.

7. <u>Habitat fragmentation/edge effects</u> – Habitat fragmentation/edge effects are typically associated with timber harvest and/or roads, however recreational trails can have similar, though typically less intense, impacts.

8. <u>Predator/competitor increased accessibility</u> - Trails, and snowmobile trails in particular, can greatly ease travel and access for species less adapted for movement in deep snows. This may cause greater rates of predation on some species and increased competition for prey for others.

9. Snag/coarse woody debris reduction – Snags and coarse woody debris are used for cover, nesting and denning, and are key habitat components for some species. These components may be lost through trail development, wood gathering around campsites, recreational site development and associated removal of "hazard" trees, and wood-cutting for firewood (though against Washington State Parks regulations, trails facilitate illegal firewood cutting).

10. Incidental mortality – Direct collision with motorized vehicles can result in incidental mortality. Snowmobiles may indirectly cause mortality of small mammals by compacting snow and collapsing subnivian tunnels.

11. Habituation – Many species will become habituated to human presence. Habituation often poses risks to animals, resulting in undesirable behaviors, poor nutrition, incidental destruction of property, and a host of other factors.

A summary of potential impact types from recreational disturbance of the 21 wildlife species is provided in Figure 1and Table 3. In many cases conflicting information exists in the literature. We chose to err on the conservative side and list all potential impact types for each species based on the scientific literature, even if current understanding of those responses is limited or a given impact is controversial. For example, debate exists as to whether lynx experience increased competition for prey (snowshoe hares) from coyotes that use snowmobile trails to access areas of deeper snow. Since the evidence is still unclear, we include this as a potential impact. Additionally, some hypothesized effects on relatively unstudied species (e.g. direct mortality of pygmy shrews from snowmobiles destroying subnivian environments) are also included. The two categories with effects on the greatest number of species are displacement/avoidance and breeding/rearing disturbance. It is not surprising that these two categories are also among the easiest to document.

Figure 1. Histogram of the number of focal species (21 possible) potentially negatively affected by impact type.

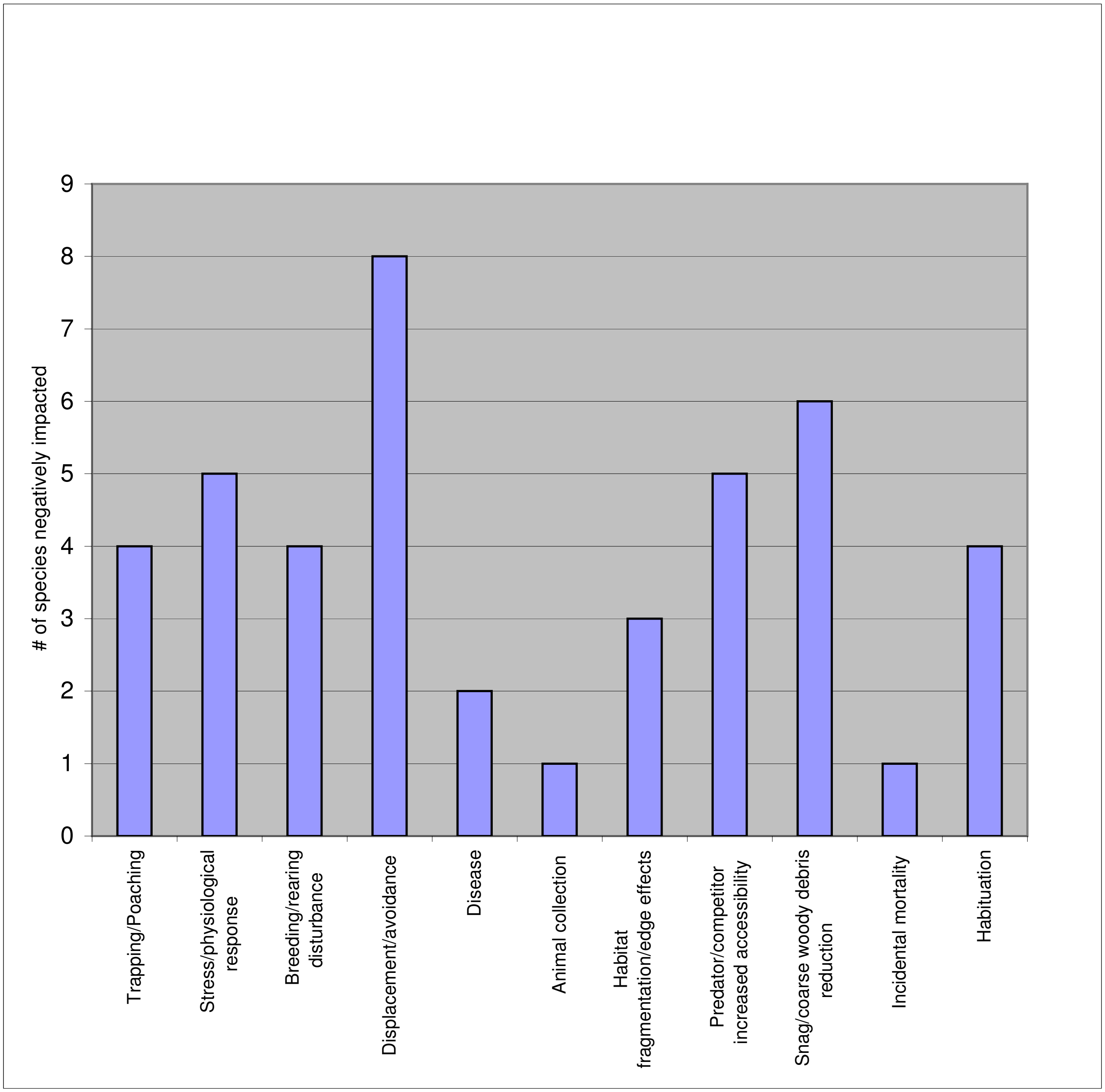

Table 3. Impact types potentially negatively affecting focal species. An "1" designates a potential impact and blanks indicate a lack of information or no known impact.

	Trapping/ Poaching	Stress/ physiological response	Breeding/ rearing disturbance	Displacement/ avoidance	Disease	Animal collection	Habitat fragmentation/ edge effects	Predator/ competitor increased accessibility	Snag/ coarse woody debris reduction	Incidental mortality	Habituation
gray wolf	1	1	1	1	1						1
lynx	1		1					1			
wolverine	1	1	1	1	1			1			
marten	1	1		1			1	1	1		
elk		1		1							1
white-tailed deer		1		1							1
moose				1							1
goshawk			1	1		1					
boreal owl											
pileated woodpecker									1		
black-backed woodpecker									1		
dusky grouse											
brown creeper							1	1	1		
winter wren							1	1	1		
olive-sided flycatcher									1		
pika				1							
pygmy shrew										1	
silver-haired bat											
hoary bat											
western toad											
Compton tortoiseshell butterfly											
Total	4	5	4	8	2	1	3	5	6	1	4

A summary of potential impact types by mode of recreation for the 21 wildlife species is provided in Figure 2 and Table 4. The classification in the figure and table includes specific recreational activities (snowmobiling, skiing, hiking, biking, and horseback riding) as well as categories for effects of trail presence/development and recreational site presence/development. In some cases species respond to the presence of humans doing an activity, while in other cases species respond to or are affected by the physical trail itself. For example, an animal may respond to the noise of a snowmobile by moving away from it, but independently, may also avoid snowmobile trails. These are considered as separate response types.

Predictability seems to be a particularly important component in level and type of species responses to human disturbance – species react most to spatially unpredictable (e.g. off-trail) activities (Taylor and Knight 2003a). Havlick (2002) notes that while roads have many negative impacts on wildlife, they can offer somewhat higher levels of predictability for wildlife than a variety of recreation types (motorized and non-motorized), which may or may not be limited to trails.

Categories for analysis of impacts by recreation type are:

1. Snowmobiles –Technological advances are increasing the type of terrain that snowmobiles can access, opening up previously undisturbed winter habitats for a variety of wildlife species. Noise, unpredictability, speed, and snow compaction associated with snowmobiles are variables that can impact wildlife. Snowmobiles can cause direct mortality of animals and are sometimes used to harass wildlife. Snowmobile use occurs in winter when many species may already be stressed by thermal regulation and food shortages (Boyle and Samson 1985).

2. Skiing – Skiing is often concentrated on trails but may unpredictably occur away from trails as well. This category includes cross-country skiing as well as telemark/backcountry skiing. Some wildlife appears more sensitive to approach of humans on foot/skis than on motorized vehicles (Parker et al. 1984).

3. Hiking/Backpacking – Hiking is the most common form of recreational activity and likely to be concentrated along trail corridors, although many visitors also hike off-trail. Hikers may affect wildlife through direct disturbance, trampling of habitat, and indirectly through discarded food and other items (Boyle and Samson 1985). Risk of human-caused wildfires, which affect wildlife and habitat, are greater with higher levels of recreation. Some species are particularly sensitive to approach of humans on foot. Hikers/backpackers can inadvertently lead to the spread of noxious weeds, reducing habitat quality for some species. Hiking is identified as the recreation type having the 2nd most negative impact on threatened and endangered species (ORVs are first) (Losos et al. 1995).

4. Mountain Biking - Mountain biking is one of the fastest growing outdoor activities. Although it is often assumed to be more disturbing to wildlife than hiking, very little empirical evidence is available to assess its impacts (Taylor and Knight

2003a). Speed and sound-levels of bikers vary from those of hikers and skiers, affecting types of wildlife responses. Being quieter (generally less talking) and quicker, in some ways, mountain biking may seem less predictable to wildlife. On the other hand, animals react most to the human form, and mountain bikers, like vehicles, may seem less threatening (Taylor and Knight 2003a). Mountain biking for the most part is limited to trail corridors, adding predictability. Bighorn sheep were found to be less sensitive to on-trail mountain bikers than off-trail hikers (Papouchis et al. 2001). Mountain bikers generally travel greater distances and thus, even if disturbance is equal to that of hiking, may provide greater disruption to wildlife on a single outing (Taylor and Knight 2003a). Mountain bikers may contribute to the spread of noxious weeds, reducing habitat quality for some species.

5. Horseback riding – Few studies document impacts of horseback riding. However, in those that do, horseback riders appear to be on the lower end of the spectrum in causing direct disturbance to wildlife (Wisdom et al. 2004, Taylor and Knight 2003a). Horseback riders may contribute to the spread of noxious weeds in wildlife habitats. Concentrations of horses around water can negatively impact habitat quality for aquatic wildlife (Vinson 1998). Horses can attract brown-headed cowbirds and potential predators of some songbirds, particularly where corrals and stables are present (U.S. Fish and Wildlife Service 2002).

6. Human presence/wildlife observation – Much of the older scientific literature describes species responses to human presence without specifying the context in terms of a recreational activity (e.g. "generally tolerant of humans", or "sensitive to human presence around den sites"). This category is used to capture that general information, and is also typically marked whenever a specific type of recreational activity, such as hiking or biking, is documented to negatively impact a species (since obviously human presence always accompanies any form of recreation). Exceptions are when the means of recreation (e.g. horses, snowmobiles) are a factor potentially impacting species' habitat, and the species is not responding to presence of the human, *per se*.

   This category also includes activities involving continuous observation/interaction with wildlife (e.g. photography, wildlife study) - more than would normally occur in the context of a passing hiker or biker. Longer and/or more frequent interactions are potentially more disturbing to wildlife, and not infrequently, rare or sensitive species may be the focus of such attention (Boyle and Samson 1985).

7. Trail development/presence – This category encompasses all trail types, including snowmobile routes. Mere physical presence of trails may cause avoidance by some species. Trails fragment habitats and provide avenues for infestations of weeds. In winter, compacted snowmobile routes may ease travel and provide increased accessibility for predators/competitors of some species. Habitat loss and reductions of key structural components (snags, coarse woody debris) may occur with trail development and maintenance of trail corridors.

8. Recreation site presence/development – This category is used to encompass areas of high recreational use other than trails, such as campgrounds, trailheads, picnic areas, etc. These sites often have altered vegetation that affects wildlife composition and abundance (e.g. higher concentrations of some small mammals, changes in diversity and type of bird species (Boyle and Samson 1985)). While potential human disruption of or interaction with an animal on a trail (whether hiking, riding, etc.) is likely to be relatively fleeting, human presence at recreational sites is generally more concentrated and of longer duration. Habitat loss and reductions of key structural components (snags, coarse woody debris) may occur with development, use (e.g. wood collecting for campfires), and maintenance of these sites.

Of the various forms of recreation, snowmobiles (the only motorized form of recreation included in this study) rank highest in terms of the number of focal species impacted (7 of 21 species) (Figure 2). Noise, speed, and ability of snowmobiles to go off-trail likely contribute to their relatively high level of impact. However, due to public interest and controversy of snowmobile regulation in parks and other natural areas, snowmobiles also have received much greater research attention than other types of recreation. Horseback riding and biking for example, are documented to affect notably fewer of the focal species (1 and 2, respectively), but very few studies even include these forms of recreation. Human presence/wildlife observation is documented to impact 9 of the 21 focal species. Presence of trails and areas of concentrated recreation/recreational development negatively impact (14 and 7 species, respectively).

Figure 2. Histogram of number of focal species potentially affected by recreation type.

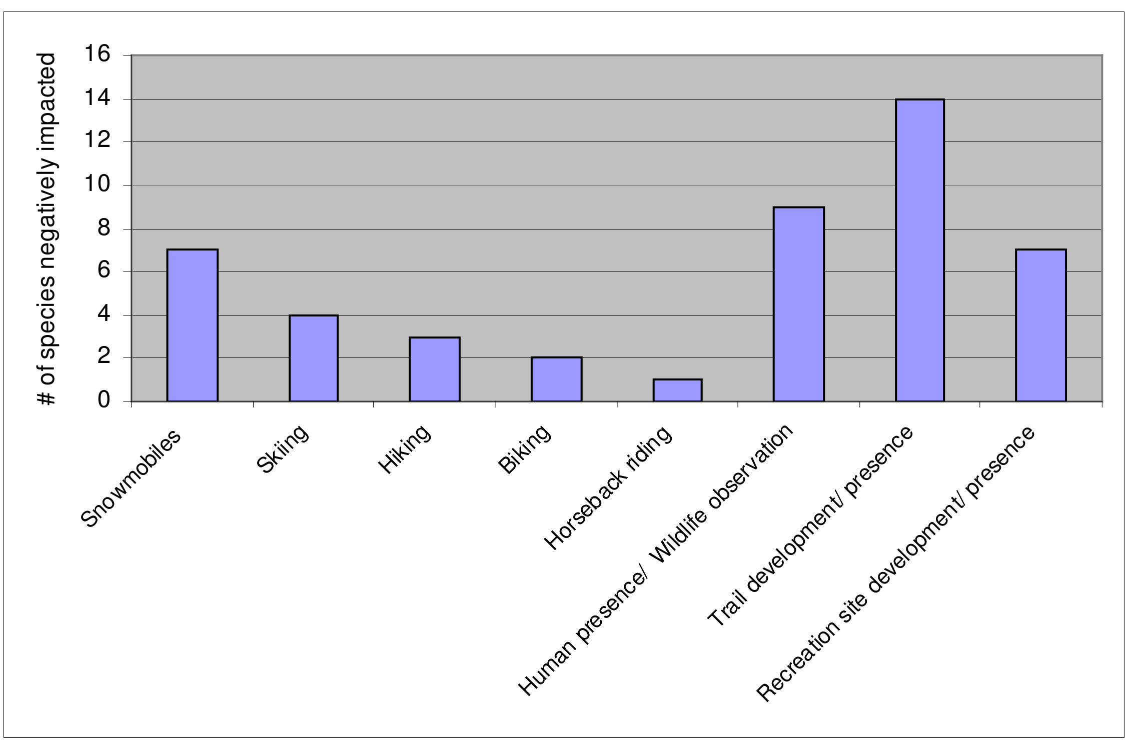

Table 4. Types of recreation potentially negatively impacting focal species. An "1" designates a potential impact and blanks indicate a lack of information or no known impact.

	Snowmobiles	Skiing	Hiking	Biking	Horseback riding	Human presence/ wildlife observation	Trail development/ presence	Recreation site development/ presence
gray wolf	1					1	1	1
lynx						1	1	
wolverine	1	1				1	1	
marten	1					1	1	
elk	1	1	1	1	1	1	1	1
white-tailed deer	1	1	1	1		1	1	1
moose	1	1	1			1	1	
goshawk							1	1
boreal owl								
pileated woodpecker							1	1
black-backed woodpecker							1	1
dusky grouse						1		
brown creeper							1	
winter wren							1	
olive-sided flycatcher							1	
pika						1		
pygmy shrew	1							
silver-haired bat								
hoary bat								
western toad							1	1
Compton tortoiseshell butterfly								
Total	7	4	3	2	1	9	14	7

Recreation impacts on species

This section contains detailed discussion of recreational impacts by species group and by species. A summary table of known impacts is provided for each species group. Recreational impacts on carnivores are summarized in Table 5. Table 6 summarizes impacts on ungulates and Table 7 summarizes impacts on birds. Small mammals impacts are summarized in Table 8. Impacts on other species (western toad and Compton tortoise-shell butterfly) are listed in Table 9.

CARNIVORES

Table 5. Detailed information on potential impacts by recreation type for carnivores.

	Snowmobiles	Skiing	Hiking	Biking	Horseback riding	Human presence/ Wildlife observation	Trails	Developed recreation sites	Other
Gray wolf	1. Snowmobile routes are associated with greater mortality/injury of wolves from traps and illegal killing (Claar et al 1999). 2. Increase in stress as measured by glucocorticoid levels with increasing snowmobile activity but no evidence of resulting decrease in fitness (Creel et al 2002). 3. Use snowmobile routes for travel (Creel et al 2002).	No information				Direct human disturbance at den and rendevous sites can cause stress and abandonment (Claar et al 1999).	Mixed response to trails - both avoidance and attraction. In winter use trails for travel and in summer more likely to avoid (Creel et al 2002, Whittington et al 2005).	No information	Domestic dogs can result in pup mortality, disease, and displacement (Boyd et al 1993, Claar et al 1999).
Lynx	1. Snowmobile routes may provide greater access for competitors (coyotes) but evidence is mixed (Kolbe et al 2007, Murray et al 2008). 2. Snowmobile routes may have greater risk of mortality/injury from traps.	No information				Direct human disturbance at den sites can cause stress and abandonment. Otherwise considered generally tolerant of humans. (Claar et al 1999).	No information	No information	No information

(continued on next page)

(Table 5 continued)

	Snowmobiles	Skiing	Hiking	Biking	Horseback riding	Human presence/ Wildlife observation	Trails	Developed recreation sites	Other
Wolverine	1. Snowmobile routes may allow greater access to winter habitats by various predators and competitors (Claar et al 1999). 2. Snowmobile routes associated with greater mortality/injury from traps (Squires et al 2007).	Negative associations of wolverine presence with helicopter and backcountry skiing (Krebs et al 2007).	*See Trails and Human presence*	No information	No information	Evidence is mixed as to whether acvtively wolverines avoid humans (Copeland et al 2007). May be sensitive near denning sites (Copeland 1996 *in* Claar et al 1999).	Appear indifferent to presence of low-use trails (Copeland et al 2007).	Evidence mixed - sometimes avoiding human infrastructure but also have been found near active campgrounds (Claar et al 1999, Copeland et al 2007).	Domestic dogs can result in mortality of young and introduce diseases (Claar et al 1999).
Marten	1. Snowmobile routes may allow greater access to winter habitats by predators (Claar et al 1999). 2. Snowmobile routes associated with greater mortality/injury from traps (Beland 2007, Claar et al 1999).	No information							Low intensity OHV (off highway vehicle) use has no apparent effect on habitat use (Zielinski et al 2008).

Gray wolf

Gray wolves historically ranged across much of North America, although humans resulted in their extirpation, and more recently, reintroduction, in numerous areas. They are listed as endangered at the federal and state level in Washington. Wolves in the Rocky Mountains prefer coniferous forests (Houts 2001).

Gray wolves are reasonably well studied in terms of human impacts. They are resilient and adaptable animals, but show a wide range of sensitivity to human presence. Claar et al. (1999) writes that wolves “can coexist with people, if people will tolerate them”. Direct human impacts are still the greatest single impediment to their recovery and survival.

Much of the literature on human disturbance of wolves is based on road access and road density. However, potential effects of trails and associated recreation (both positive and negative) have also been studied. Recreation-related risks to wolves include displacement, increased stress levels, spread of disease, injury, and direct mortality.

Trails provide increased access to backcountry areas where wolves may otherwise have been relatively free from human disturbance. Snowmobile trails in particular are associated with increased levels of legal and illegal trapping (Claar et al. 1999). Although it is illegal to trap wolves in Washington, wolves are known to use snowmobile routes for easier travel in winter (Claar et al. 1999) and are vulnerable to traps set for other species. Numerous instances are reported of wolves being killed or losing limbs associated with leg hold traps and snares (Claar et al. 1999).

While acceptance of wolves in the wild has increased dramatically since they were brought to the brink of extinction by human persecution in the 1940’s, many people still dislike wolves and intentional killing of wolves is a documented problem in some areas (Claar et al. 1999). Increased trail access provides greater opportunities for those wishing to do physical harm to wolves.

From an opposite point of view, wolves fascinate many people and disturbance resulting from wildlife viewing and wildlife photography, though typically unintentional, may cause harm to wolves. Recreational wildlife viewing may cause abandonment and relocation of den and rendezvous sites, increasing stress in adults and risking injury or death to pups (Claar et al. 1999). Wolf pups are particularly vulnerable during the first 3 weeks of life when they cannot maintain their own body temperature, and any disturbance that keeps the females away from the den poses risks to the pups (Mech 1970). In Yellowstone National Park, wildlife watching by tourists is reported to have contributed to the death of a litter of wolf pups (Claar et al. 1999).

Wolves vary widely in their response to direct human presence. This appears to be true across geographic areas and even within wolf packs. While some wolves may abandon a site with extremely limited human encounters, others tolerate higher levels of disturbance (Thiel et al. 1998). Claar et al. (1999) describes how the Ninemile wolves in Montana abandoned their summer rendezvous site after someone unintentionally walked into it once, but 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 over flights”.

Habituation of wolves to human presence sometimes occurs, and recovering populations are more likely to become habituated than newly colonizing wolves (Thiel et al. 1998). While habituation may reduce stress for wolves in the short term, it is not necessarily a positive long-term response. Habituated wolves may be more likely to predate on domestic livestock and habituated wolves run greater risks in being targets for illegal killing (Claar et al. 1999).

Another form of risk to wolves comes from recreation-related presence of domestic dogs in wild areas. Many people choose to hike, ski, and camp with domestic dogs. Dogs that encounter and disturb wolves at dens or rendezvous sites may result in wolves abandoning those sites (Claar et al. 1999). Any time wolves are required to relocate pups, there is an increased risk of mortality. Domestic dogs also may carry diseases to which wild wolves are susceptible. There are documented cases in Glacier National Park and Isle Royale National Park of domestic dogs introducing canine parvovirus to wolf populations, leading to increases in mortality of wolf pups (Boyd et al. 1993). Rabies, distemper, and parasites can easily be transferred from dogs to wild wolf populations (Claar et al. 1999). Wolf and domestic dog interactions also sometimes result in the death of pets. This can lead to pet owners supporting the "removal" of the wolves.

The literature varies as to whether wolves are drawn to, or avoid roads, trails, and other human developments. In Isle Royale, wolves use park trails for travel but reduce use with arrival of visitors in the spring (Peterson 1977 *in* Claar et al. 1999). Whittington et al. (2004) found that both roads and trails altered wolf movements across their territories. Although wolves avoided crossing high-use roads more than low-use trails, trails appeared to affect movement behavior of wolves as much, if not more than roads.

Whittington et al. (2005) state that roads, trails and other human developments can cumulatively affect local distributions of wolves through habitat fragmentation, loss and degradation. They found that many studies of wolf responses to roads, trails and human activity conducted at a broad scale find avoidance, while finer scale studies have found tendencies for attraction. Whittington et al. (2005) explain this difference as based on density of people. Most landscape studies (where wolves avoided roads) occurred in populated areas while the finer scale studies where wolves were attracted to such areas were in more remote areas. In studying a populated area at a fine scale (Jasper, Alberta), Whittington et al. (2005) found wolves selected low-use roads and trails as travel routes more often than high-use roads and trails and avoided areas of high road and trail density (1.3 and 2.9 km/km-squared, respectively). Wolves traveled five times further on low-use trails than high-use trails.

Hebblewhite and Merrill (2008) found that "in areas of low human activity, wolf resource selection was independent of proximity to humans". With increasing human activity wolves were in general found closer, but avoided use of such areas during daylight hours. Like Whittington et al. (2005), their findings suggest wolves respond more to levels of human density/activity than density of actual trail/road networks.

Recreation trails provide a mix of advantages and disadvantages for wolves. Wolves will preferentially use trails for travel corridors. In winter, snowmobile trails, cross-country ski trails, and roads make snow travel easier (Creel et al. 2002). Wolves will generally avoid travelling through snow >50 cm in depth and by traveling on snow-compacted routes, wolves reduce energy expenditure and may even gain greater hunting access to prey populations that may previously have been more difficult to reach (Claar et al. 1999).

However, risk of mortality associated with humans is also notably greater along human linear features. In the central Rockies, 21 of 25 human-caused wolf mortalities occurred within 200 m. (shooting distance) of a human linear feature (Boyd and Pletscher 1999 *in* Claar et al. 1999). Wolves experience higher stress, as measured by fecal glucocorticoid levels, in association with areas and times of heavy snowmobile use (Creel et al. 2002). Such stress, however, has not yet been linked to decreases in fitness or population size.

The impact of trails and recreation levels varies by season (Hebblewhite and Merrill 2008). In winter, wolves are concentrated in valley bottoms near ungulate winter ranges. Many roads and trails tend to run along these bottoms. Dense trail networks and high use areas along the base of steep-sided mountains or narrow movement corridors may inhibit use of these productive areas by wolves. In summer, wolves are less geographically restricted and may avoid trails and roads to a greater extent (Whittington et al. 2005).

Management considerations

Levels of human disturbance to wolves can be lessened in a variety of ways. Areas around den sites and rendezvous sites should be closed to recreation. Stephenson and Ahgook (1975) reported the greatest distance at which wolves at a den could detect humans as 1.5 km. In Yellowstone, Mech et al. (1991) recommended closing a 1.6 km radius around denning areas 1 month before and 2 months after denning. In Denali National Park, Chapman (1977) recommended a 2.4 km radius area closed for 1 month prior to and 3 months after denning. (All references *in* Claar et al. 1999).

New recreation opportunities should be concentrated where displacement of wolves has already occurred and discouraged in areas where displacement has not yet occurred (Purves et al. 1992 *in* Claar et al. 1999). For example, existing backcountry campgrounds should be enlarged as needed, rather than new ones developed, and additional trails should be established in areas with a current focus on recreational opportunities (Peterson 1977 *in* Claar et al. 1999).

Lynx

Lynx are listed as both a state (WA) and federally threatened species. Lynx in Washington are at the southern edge of their geographic range. Low population densities, habitat fragmentation, and potential effects of climate change on snowshoe hare, a primary prey species, are issues affecting lynx conservation (McDonald 2008).

Investigation of recreational impacts on lynx has been limited. Behaviorally, lynx are generally tolerant of humans, but also exhibit a wide variety of behavioral responses to human presence (Ruediger et al. 2000). "Trappers report that lynx show little fear of human scent, and may become bolder when prey is scarce" (Mowat et al. 1999). Anecdotal reports note that moderate levels of snowmobile traffic and ski area activities have not displaced lynx (Mowat et al. 1999, Roe 1999 *in* Ruediger et al. 2000). Preliminary information also suggests that lynx do not avoid roads except at high traffic volumes (Apps 2000). However, lynx can be sensitive to human activities around den sites in late May and June. This may lead to abandonment of the site, possibly affecting kitten survival (Claar et al. 1999).

Winter habitat and the potential effects of compacted snow routes on increasing interspecific competition for prey has been the primary focus of research related to lynx and recreation. Lynx, with their large feet, are well adapted for hunting snowshoe hares (their primary prey species) in deep snow conditions. Other predators of hares, such as coyote, gray wolf, mountain lion, bobcat, and wolverine have a higher "foot-load", requiring these species to expend notably more energy to traverse deep snows while hunting (Claar et al. 1999). Of these species, coyotes are considered the most likely to negatively affect lynx through competition in winter (Buskirk 1999). There is concern that a rise in snowmobile recreation and associated snow-compacted routes may allow coyotes a competitive advantage in areas of deep snow from which they have historically been excluded. This in turn, may contribute to lynx starvation and reduced recruitment (Ruediger et al. 2000), and have a particularly strong effect in the southern part of the lynx's range where hare numbers are low (Buskirk 1999). Kolbe et al. (2007) note that although skiing and snowshoeing also result in compacted snow trails, only snowmobiling is likely to create a trail system dense enough to affect predator communities.

The evidence of snowmobile trails allowing increased competition for prey by coyotes in winter is mixed however, with more recent literature questioning the validity of this hypothesis. In the Uinta Mountains of Utah, Bunnell et al. (2006) found coyote tracks were associated with snowmobile trails and that use of such trails was related to snow depth and prey density. In western Montana, Kolbe et al. (2007) felt that despite coyote presence in lynx habitat year-round, interspecific competition was low. They found that in the winter coyotes were primarily scavengers and hares (primary prey of lynx) made up only a small proportion (3%) of their diet. Also, coyotes did not use compacted snow routes more than would be expected by random, and scavenge and kill sites were not located closer to these routes than would be expected by random. Murray et al. (2008) also question whether competition from coyotes adversely affects lynx. They write "… exactly how coyotes could functionally and significantly displace or outcompete lynx if they are largely restricted to hard-packed trails is unclear". They also express concern about management agencies apparently accepting the hypothesis of increased competition from coyotes along snow-packed routes "without strong empirical support" and further scrutinizing.

Although trapping of lynx is illegal in Washington, presumably lynx are vulnerable to traps set for other species. Snowmobile routes facilitate both legal and illegal trapping (Claar et al. 1999) and may add represent areas of greater risk for injury and mortality of lynx from traps.

Management considerations

A number of management suggestions to reduce potential negative impacts on lynx from recreational activities have been suggested. These include minimizing activities that increase levels of snow compaction in lynx habitat until research provides clearer information on the influence of snow-compacted routes on competition for prey (Claar et al. 1999). Bunnell et al. (2006) found that coyotes primarily used *persistent* snowmobile trails, and thus recommend that areas be managed for snowmobile use on a rotating, rather than continual basis.

Apps (2000) suggests that lynx may be able to adapt to regular and concentrated recreational use as long as adequate security habitat is available, since most human activity occurs during the day and lynx are most active dusk to dawn. Sites with tangled woody debris, similar to denning habitat, are difficult for humans to access and can provide such security.

Disturbance around denning habitat should be minimized from May to August (Apps 2000).

Wolverine

Wolverines occur in boreal forests, tundra and western mountains. Wolverines generally prefer high elevation habitats throughout the year, with habitat use varying geographically and by season. Subalpine cirques are important habitat for natal denning (Claar et al. 1999). Wolverines are distributed across northern North America, extending down into the US in mountain ranges such as the Cascades and Rocky Mountains. A federal species of concern, and a Washington state candidate species, wolverine populations have recently increased in response to the diminished pressures of the fur trade and human settlement (Hash 1987).

Wolverines are most often found in areas of low human density and numerous studies indicate an active avoidance of human activity by wolverines. However other scientists question whether wolverines are actually avoiding humans, or whether association of wolverines with roadless and wilderness areas is simply an artifact of their preference for higher elevation habitats (Copeland et al. 2007).

Domestic dogs and trapping are two recreation-related concerns that may have direct impact on wolverines. Unleashed domestic dogs may result in direct or indirect mortality of young wolverines, and may introduce diseases to which wolverines are susceptible (Claar et al. 1999). Roads and trails developed for recreation (snowmobile trails in particular) allow greater access for trapping and therefore may increase risk of injury and mortality of wolverines from traps (Squires et al. 2007). Snowmobile and ski trails, by providing packed snow paths, may also allow greater access by a variety of predators and competitors to wolverine habitats (Claar et al. 1999).

Most of the recreation-related literature for wolverines involves indirect impacts, such as potential displacement of animals as a result of skiing, snowmobiling, road and trail networks. However, the literature is mixed with evidence of wolverines using, avoiding, and indifferent to areas of human activity.

Sensitivity of wolverines to human presence has been a commonly held viewpoint, and is supported by a number of studies reporting "spatial separation of wolverines and human-related infrastructure" (Copeland et al. 2007, Carroll et al. 2001, May et al. 2006). Hornocker and Hash (1981) suggested that human access via snowmobile or all-terrain vehicles in winter or early spring could disturb wolverines. Copeland (1996) (*in* Claar et al. 1999) suggested that subalpine cirque areas, which are important for wolverine natal denning, may be rendered unavailable by winter recreational activities. Rowland et al. (2003) assessed landscape models for wolverines in the interior Northwest and found that road density and human population density were better predictors of wolverine counts than amount or class of habitat.

In the Columbia Mountains, British Columbia, habitat use by wolverines was found to be negatively associated with helicopter skiing at a landscape scale, and backcountry skiing at a mesoscale (Krebs et al. 2007). Associations were stronger for female wolverines than males. The researchers found high value of alpine and subalpine habitats for wolverines in summer and note the "unknown cumulative risk" of increasing recreation pressure in these areas. They raise a concern that "wolverines may respond in a threshold rather than linear manner once ecological resiliency is exceeded".

Counter to the prevailing view of wolverine sensitivity to humans, a study conducted in central Idaho found that wolverines showed no attraction to or avoidance of trails during the summer (although they avoided roads) (Copeland et al. 2007). It was unclear whether the apparent indifference to trails was due to the low frequency of trail use by recreationists, or whether wolverines were insensitive to human presence. In the same study, wolverines were not uncommonly found near active campgrounds, lending credence towards a lowered sensitivity to people. Wolverines were found to use unmaintained winter roads for travel. However the authors note that the roads data may be confounded since most roads in the study area were at lower elevations. The authors concluded that wolverines in their study most likely used high-elevation areas because of a preference for those habitats rather then to avoid human activity.

While a number of studies seem to indicate some form of behavioral response by wolverines to human activity, we could find no data on long or short-term potential implications for populations or individuals.

Claar et al. (1999) speculate as to likely physiological responses of wolverines to human-caused disturbance, based on evidence of other wildlife species. These include "elevated heart rate, metabolism, blood sugar, body temperature, respiration rate and depth, oxygen consumption, and brain and heart blood flow", all of which have associated energetic costs.

Management considerations

Until further studies clarify the impacts of various forms of human recreation on wolverines, caution and a conservative approach should be used in recreation management in wolverine habitat. Some recommendations for reducing recreation impacts on wolverines are offered by Claar et al. (1999). Managers should avoid placing new recreational trails and roads through previously unfragmented habitats. As a species naturally occurring at low densities, wolverines are susceptible to habitat fragmentation and population isolation. Roads and trails should be located away from potential denning areas.
Natal and kit-rearing habitat should be protected from disturbance from January 1st through May 30th. Female wolverines are sensitive to disturbance at den and rendezvous sites. Copeland (1996) (*in* Claar et al. 1999) documented den desertion in Idaho.

Marten

Marten are broadly distributed in Canada and the United States, ranging from New Mexico to the northern tree limit in Alaska and Canada, and from the west coast east to Newfoundland. In the western United States below Alaska, populations are limited to mountain ranges providing preferred habitat. Martens use late-successional mesic forests for most habitat needs, including denning, resting, foraging, thermal and escape cover. Forested riparian habitats and meadow edges are also important foraging habitats. In most of the west, marten are managed as a furbearer, with regulated harvest. Due to their dependence on old-growth forest, marten are also commonly designated by land management agencies as a sensitive or indicator species (Claar et al. 1999). Martens are not listed federally, nor are they a species of concern in Washington State.

There has been little study of recreation influences on marten. Most literature related to human effects on marten is associated with mortality from trapping and habitat loss due to timber harvest. Recreation can contribute to habitat loss, as structures important to marten, including snags and downed logs, may be removed during the development of new trails and recreational sites. These effects are likely to be relatively minor, however. Claar et al. (1999) suggested that snowmobile trails provide increased access for trappers (both legal and illegal) and increase the risk of mortality to furbearers and other carnivores. A recent 4-year study in a national park in Michigan evaluated marten mortality from trapping and other causes. Beland (2007) found that although most mortality was human-caused (trapping and vehicle collisions), levels were sustainable allowing for population growth. The author stresses the importance of continual assessment of human mortality on marten populations.

As marten are often associated with remote wilderness conditions, there is speculation that human activity may cause displacement and other negative impacts on marten. In the absence of empirical data, Claar et al. (1999) speculated that physiological responses of marten to human-caused disturbance may include "elevated heart rate, metabolism, blood sugar, body temperature, respiration rate and depth, oxygen consumption, and brain and heart blood flow", all of which have associated energetic costs. Marten may be particularly vulnerable to energetic costs of disturbance in winter months, when thermoregulation is important. In addition, they suggest that snow compaction along snowmobile routes may permit increased access of predators (e.g. coyotes) to marten habitat and that OHVs may also affect marten prey populations. As a species that occurs in relatively low densities, with limited reproductive and dispersal capabilities, Claar et al. (1999) suggest that marten are predisposed to negative consequences of habitat fragmentation and population isolation. Recreational activities that result in displacement may have a disproportionately large impact on such species.

A recent study in California empirically assessed potential impacts of human recreation on marten (Zielinski et al. 2008). They evaluated marten vulnerability to disturbance by OHVs by measuring occurrence of marten in OHV and non-OHV areas. They found no effects on marten use of the two areas. They state that OHV use was relatively low even in the "use" area (approximately 0.5 vehicle passes/hour) and that more intensely used areas may produce greater effects. Most OHV occurred during the day when marten are relatively inactive and this likely reduced disturbance of marten, although there may have been other physiological, behavioral, or demographic responses not detected by the study (Zielinski et al. 2008).

Management considerations

Maintaining sites where motorized recreation is minimal or completely restricted, in close proximity to more intensely used areas may allow persistence of martens in diverse landscapes (Zielinski et al. 2008). New roads and trail routes should avoid separating mature, closed canopy forests from marten foraging habitats (Claar et al. 1999). Refugia, or areas restricted from trapping, are important for dispersal and immigration of marten to other areas with higher, human-caused mortality (Claar et al. 1999). Providing undisturbed, suitable resting sites for marten is particularly important in winter as they are small-bodied and not as efficient at retaining body heat as larger carnivores (Banci 1989 *in* Claar et al. 1999).

UNGULATES

Ungulates are a major source of recreational opportunity and thus receive a great deal of attention and research interest. Recreation opportunities associated with ungulates are important economically, generating substantial local and state revenue from hunters, wildlife observers and photographers (Canfield et al. 1999).

Recreational information (except hunting) on ungulates is primarily based on negative impacts from direct disturbance. Often disturbance levels are described in terms of observed behaviors, and are measured as alert distance (AD), flight initiation distance (FID), and distance moved (DM). FID appears as the most common measure, but it can be misleading. In areas (or seasons) where alternative sites from disturbance are limited, ungulates may have notably shorter FIDs, leading to a misperception of habituation or lack of effect of disturbance on the animals (Stankowich 2008). Differences in body condition can also confound these disturbance measures as animals in poor condition, with less energy reserves, may flee at shorter distances than healthier animals (Stankowich 2008).

Ungulate responses to human recreation range from "an increase in general alertness to a slow retreating movement to outright flight, depending on the ungulate species and the type of disturbance" (Canfield et al. 1999). Stankowich (2008) identified a number of generalized behavioral responses of ungulates to human disturbance, though he noted a high degree of heterogeneity in responses across and within species. He found that the faster and more direct the approach from a human, the greater the FID. Time of day had no clear effect on flight responses for non-hunted populations, but hunted populations were more sensitive at dusk and dawn, and hunted populations had higher responses in general than non-hunted populations. Ungulates with more frequent human contact show reduced flight responses compared to those with less contact. Females with offspring generally exhibit greater flight responses than males or females without young. Ungulates in more open habitats were more responsive to disturbance than those in forests. Humans with dogs elicited equal or greater responses than humans alone, but the flight response is stronger towards the human than the dog. Humans on foot are far more evocative than humans associated with vehicles, bicycles, or cars, or anthropogenic noise alone. Lastly, humans hiking off-trail led to greater responses than on-trail hikers.

Even when animals show no apparent behavioral response, studies have shown that animals may experience physiological stress (Creel et al. 2002). In theory such stress, over time, may create greater susceptibility of animals to disease, lower reproduction, and other negative consequences (Sapolsky 1992 *in* Creel et al. 2002).

Ungulates have greater vulnerabilities to disturbance with potentially higher consequences at key times throughout the year. Winter is a stressful time, with relatively little forage and higher energy expenditures for thermal regulation and movement in snow. Winter ranges tend to restrict ungulates to lower elevations with higher densities of roads and trails, and greater human use (Canfield et al. 1999). Displacement of deer and elk from winter ranges on public lands can have a highly negative consequence of shifting use to private lands. Concentrations of deer and elk on private lands can result in property damage, habituation of animals, and even potentially drawing predators, such as mountain lions, closer to human habitations (Canfield et al. 1999).

Early spring is another critical time, when deer and elk are often at their lowest physical condition of the year. Areas of early snowmelt (low elevation, south-facing slopes) provide important forage opportunities for deer and elk to restore energy reserves lost during winter. These areas are also attractive for people wishing to recreate outdoors in the early spring, away from snow. Canfield et al. (1999) write that in early spring "animals may succumb to stresses that would be considered minor at other times of the year" and that "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 year". Although energy reserves are at their highest in the fall, hunting restricts ungulate movements and results in higher stress levels and energy expenditures.

Numerous studies have been conducted on ungulate responses to snowmobiles, skiers, and hikers. Surprisingly, snowmobiles seem to cause less response than humans on foot. Parker et al. (1984) notes greater flight distances by deer and elk to skiers and individuals on foot than snowmobiles, and that flight distances decline from early to late winter as animals become habituated and energy reserves are depleted. However, Aune (1981) concluded that in Yellowstone National Park, winter recreation was not a major factor affecting wildlife, even though some displacement was observed. Taylor and Knight (2003a) found "ungulates fled at greater distances from off-trail hikers compared to on-trail hikers".

Canfield et al. (1999) summarize their review of recreation impacts on ungulates by stating, "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". Very little is known, however, about the extent to which behavioral or physiological responses from disturbance cause changes in individual fitness or population parameters of ungulate species.

Recreation impacts on ungulate species (Rocky Mountain elk, white-tailed deer, and moose) are summarized in Table 6.

Table 6. Detailed information on potential impacts by recreation type for ungulates.

	Snowmobiles	Skiing	Hiking	Biking	Horseback riding	Human presence/ Wildlife observation	Trails	Developed recreation sites
Rocky mountain elk	Minimal behavioral response in Yellowstone (White et al 2005). Increase in stress as measured by glucocorticoid levels with increasing snowmobile activity but no evidence of resulting decrease in fitness (Creel et al 2002).	Daily movement away from heavily used x-country ski trails (Ferguson 1982). Flight responses from skiers within 650 meters (Cassirer et al 1992).	Sensitive (flight response) at distances of 500 meters or less (Wisdom et al 2004).	Sensitive (flight response) at distances of 1500 meters or less. Flee further distances than bikers from hikers or horseback riders. (Wisdom et al 2004).	Sensitive (flight response) at distances of 500 meters or less. Slightly less sensitive to horseback riders than hikers or bikers. (Wisdom et al 2004).	Can be sensitive to human presence, but also may habituate, conserving energy (Thompson & Henderson 1998).	Daily movement away from heavily used x-country ski trails (Ferguson 1982).	Can be sensitive to human presence around heavily used recreation sites, but also may habituate, conserving energy (Thompson & Henderson 1998).
White-tailed deer	Wide array of responses to snowmobiles, varying by study. Range from potential benefit, by providing compacted snow trails, to short-term avoidance, increase in stress levels, to reductions in home ranges. (*See text for details).*	Mule deer responses from skiiers involve more running and are of greater duration than for disturbance from snowmobiles (Freddy 1986a, Freddy et al 1986).	Alert and flush distances for mule deer were lower for a hiker alone than with a dog. Mean alert distance on-trail (in a forested setting) for a lone hiker was 46 m. and flush distance was 34 m. With a leashed dog, distances were 85 and 49 m. respectively (Miller et al 2001). Distance at which mule deer flushed from off-trail hikers was 4 times that of on-trail hikers. Mule deer show 70% probability of flushing from hikers at distance of 100 meters (Taylor and Knight 2003a).	No information on white-tailed deer, but mule deer show 70% probability of flushing from on-trail bikers at distance of 100 meters in an open environment (same as for hikers) (Taylor & Knight 2003a).	No information.	Respond to human presence associated with various forms of recreation - show physiological response, displacement and avoidance.	Snowmobile trails may enhance mobility of deer in snow (Richens and Lavigne 1978 *in* Boyle and Samson 1985)	In developed areas, white-tailed deer were found to become increasingly nocturnal and secretive and to use greater cover during the day (Vogel 1983 *in* Canfield et al 1999).

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(Table 6 continued)

	Snowmobiles	Skiing	Hiking	Biking	Horseback riding	Human presence/ Wildlife observation	Trails	Developed recreation sites
Moose	Repond to snowmobiles by changing behavior within 150 meters when foraging, and 300 meters when bedding (Colescott and Gillingham 1998).	Displacement and avoidance of heavily-used cross-country skiers and ski trails (Ferguson and Keith 1982).	*See Human presence*	No information.	No information.	Tolerance to humans varies by situation - habitat, social groupings, nutrition, reproductive status, & individual animals. During fall hunting, max. approach distance is 200-300 yards (Altman 1958). Habituate to wildlife watching pressure (McMillan 1954).	Avoidance of heavily used cross-country ski trails (Ferguson and Keith 1982). Avoidance of powerline corridors (Joyal et al 1984 *in* Laurien et al 2008).	No information.

Elk

Elk occur in 21 states and 6 provinces of North America. Elk in the west are found primarily in coniferous forest associated with mountains, foothills, or canyon rangelands (Skovlin et al. 2002). The most productive habitats for elk are provided by landscapes with a mosaic of forested stands (for cover) and open habitat patches (for foraging). Elk are hunted and managed as a game species in Washington.

An abundance of literature exists on the sensitivity of elk to roads (Rowland et al. 2003). Roads provide increased access for hunters and poachers resulting in substantially higher mortality of elk in areas of greater road densities (Rowland et al. 2005). To a lesser extent, trail-associated impacts of motorized and non-motorized recreation on elk have been studied. Elk respond to a variety of recreation-related disturbances by avoidance, displacement, and through physiological stress responses.

Elk are particularly vulnerable to negative impacts from recreation during winter and early spring when body conditions are poor and energy reserves are low. In winter, elk concentrate along valley bottoms and lower elevations. Roads and recreational trails often run through these areas, leading to higher levels of elk-human interactions. Elk may habituate to repeated, predictable and harmless human disturbance, in an effort to conserve energy. Such habituation near urban fringes can cause numerous problems for elk and human residents (Thompson and Henderson 1998).

Recreation at higher elevations and in more remote areas affects elk in their summer ranges. Elk have high energy requirements in summer (re-building fat reserves for winter, calf growth, lactating females and males growing antlers and preparing for rut). Increasing levels of recreation on summer range run the risk of displacing elk from higher quality foraging habitats and thus decreasing fitness and chances of over-winter survival (Canfield et al. 1999).

Morgantini and Hudson (1979) found that increased disturbance of elk during hunting season caused elk to reduce their use of higher quality open grasslands and resulted in overgrazing of marginal areas. Canfield (1984) (*in* Canfield et al. 1999) found that elk use open, productive habitats near human activity more often at night than during the day.

In the Blue Mountains of Oregon, Wisdom et al. (2004) assessed elk flight responses to ATVs, mountain bikes, horseback riders and hikers. They found that at close distances (less than 500 meters [0.3 miles]), probability of a flight response from ATVs, mountain bikes and hikers was 0.65, and was slightly lower (0.55) for horseback riders. While elk were less likely to flee from hikers and horseback riders beyond 500 meters (1600 feet), their flight response for ATVs and mountain bikers did not decrease until distance from the disturbances increased to 1500 meters (0.9 miles). Elk also moved further distances when fleeing ATVs and mountain bikes than for horseback riders or hikers.

Several studies address the impact of snowmobile activity on elk. A study in Yellowstone National Park found generally minimal behavior response by elk to snowmobiles and snow coaches, although responses did vary by the location of animals, interaction times, number of people and number of animals in a group (White et al. 2005). Another Yellowstone study however, showed that snowmobile activity caused higher stress levels in elk, as measured by fecal glucocorticoid (GC) levels (Creel et al. 2002). The higher the snowmobile activity, the higher were the hormone levels. Also, GC levels were higher for snowmobiles than wheeled vehicles. Although stress levels in the studied elk population did not appear to have immediate consequences in terms of survival of adults or juvenile recruitment, the authors suggest that GC levels "provide a sensitive method of measuring stresses engendered by human activities prior to demographic responses or changes in population size". Chronically high levels of GC can suppress immune function and functioning of the hypothalamic-pituitary-gonadal axis (Sapolsky 1992 in Creel et al. 2002). Based on captive mammal research, prolonged GC levels are expected to reduce survival and reproduction (Sapolsky 1992 *in* Creel et al. 2002). Chabot (1991) found human disturbance elevated heart rates of elk, resulting in relatively high energy expenditures.

Ferguson et al. (1982) assessed impacts of cross-country skiing on moose and elk in Elk Island National Park, Alberta. Although elk tended to move away from heavily-used trails during ski season, the general overwinter distribution of elk was not affected. Day-to-day movements away from the trails did not increase in relation to greater ski traffic. Cassirer et al. (1992) found that 75% of elk flight responses occurred 650 meters (0.4 miles) or less from skiers.

Management considerations

Minimizing recreational disturbance on winter range and areas of early spring foraging can reduce negative impacts on elk. This may require closing some trails/routes and re-routing recreational activity as needed. Foraging and cover areas should not be separated by trails and open ridges should be avoided. Topography can be used to serve as a noise and disturbance buffer (Canfield et al. 1999).

White-tailed deer

White-tailed deer are a widespread species, found throughout the U.S. and Canada. They are generalists and use a variety of forested and open habitats, feeding on grasses, forbs and shrubby browse. White-tailed deer are hunted and managed as a game species in Washington.

Factors such as cover, animal condition, level of prior human contact, group size, sex, age, interactions of these factors and others, affect how various forms of recreation impact deer (Canfield et al. 1999). Deer respond to disturbance by increased alertness, flight response, elevated heart rate and stress levels. It is unclear however, how such responses affect individual survival or population rates. Many recreation-related studies of deer are based on mule deer rather than white-tailed deer. Although responses may vary somewhat between the species, they are likely related and thus we include relevant recreation-based literature for mule deer. We compiled the white-tailed deer information in figures and tables of this report with the assumption that, if mule deer are documented as negatively impacted by a particular recreation type, white-tailed deer would also have a negative response (though specifics, such as response distances, etc. will undoubtedly vary between species) .

Taylor and Knight (2003a) found little difference in alert distance, flight distance or distance moved by mule deer for on-trail mountain bikers versus on-trail hikers, but mule deer had greater responses to off-trail than on-trail recreationists. Responses also varied by distance of the animal to the recreationist on the trail and amount of cover. At 100 meters (300 feet) distance from a trail, mule deer showed a 70% probability of flushing. Off-trail, a 70% probability of flushing was associated with a distance almost four times as great (390 meters [1300 feet]). Flight distances were greater in the morning, with tolerance for recreationists increasing during the day. Response distances tended to increase with group size, perhaps due to the greater likelihood of a group containing warier animals that in turn influence the behavior of others. This study was conducted in a generally open environment and the authors state that in more closed, forested environments, detection distances, and thus alert and flight initiation distances are likely to be shorter.

Findings by Miller et al. (2001) also supported an increased response of deer to off-trail versus on-trail recreation. They found that alert and flush distances of mule deer in a forested setting were lower for on-trail hikers than off-trail hikers, and also for hikers alone, rather than hikers with a dog. Deer became alert and flushed for on-trail hikers without a dog at 46 meters (150 feet) and 34 meters (112 feet) respectively. With a dog on a leash (on-trail), those distances increased to 85 meters (280 feet) and 49 meters (160 feet).

Many researchers have investigated the response of deer to snowmobiles. Responses vary by study, and range from no apparent impact to avoidance. Some have suggested that snowmobile trails may enhance mobility of deer in snow (Richens and Lavigne 1978 *in* Boyle and Samson 1985). Bollinger et al. (1972) (*in* Canfield et al. 1999) report deer were not driven out by snowmobiles. Dorrance et al. (1975) found significant displacement and increased movement of deer related to snowmobiles. Others documented some avoidance when snowmobiles were present, but found no significant changes in home range or daily movement patterns (Eckstein et al. 1979). Huff and Savage (1972) found that size of white-tailed deer home ranges were reduced and deer were forced into less preferred habitats in areas with high levels of snowmobile use. Snowmobiles have been shown to cause physiological stress to white-tailed deer (Moen et al. 1982). Snowmobiles appear to be less disturbing to deer however, than people on foot. Freddy (1986a) (*in* Canfield et al. 1999) and Freddy et al. (1986) found mule deer responses from skiers involved more running and were of a greater duration than were responses from snowmobiles.

Deer have been found to use temporal avoidance as well as spatial avoidance of human disturbance. In developed areas, white-tailed deer were found to become increasingly nocturnal and secretive and to use greater cover during the day (Vogel 1983 *in* Canfield et al. 1999). In an interesting study assessing level of human disturbance required to modify behavior of mule deer, Yarmoloy et al. (1988) found that intentional harassment of deer for only 9 minutes/day for 15 days resulted in the deer shifting to nighttime feeding and greater use of cover.

Even in the absence of visible behavioral responses, human disturbance has been shown to cause physiological stress responses, such as elevated heart rates, in white-tailed deer (Moen 1978). Chronic levels of stress can in turn weaken the systems of animals predisposing them to disease, lowering reproduction, and having other negative impacts (Sapolsky 1992 *in* Creel et al. 2002).

Various forms of recreation, biking, hiking, and horseback riding, can indirectly have a negative impact on deer through the spread of noxious weeds into backcountry areas. Weed infestations can lower forage quality for deer, reducing nutritional condition and making animals more vulnerable during winter and other critical times of the year (Canfield et al. 1999).

Management considerations:

Minimizing recreational disturbance on winter range and areas of early spring foraging can reduce negative impacts on deer. Closures can help prevent disturbance of animals during such times of stress. New trails should follow existing edges between habitat types, but avoid completely restricting movement between cover and forage habitats. New trails should avoid water and forage resources, wildlife travel corridors and escape terrain (Canfield et al. 1999). Encouraging visitors to stay on trails will improve predictability of recreation and lower disturbance to deer (Taylor and Knight 2003a).

Moose

Moose are widely distributed, occurring in northern boreal forests. They browse in open, shrub-dominated habitats, near lakes and wetlands. They also utilize the protection of mature conifer forests for cover and forage. In Washington they are managed as a priority game species.

A number of studies have been conducted on moose responses to roads, but few on moose responses to trails or recreation. Moose appear to avoid roads and corridors up to 500 meters (1600 feet) from roads, at coarse scales. Salt availability and shrub vegetation can attract moose to roads at finer scales (Laurian et al. 2008). Joyal et al. (1984) (*in* Laurien et al. 2008) found that moose avoid power line corridors, with stronger avoidance as width increases.

Moose have varying reactions to direct disturbance from humans. Many older natural history studies contain anecdotal information on moose responses to recreation, but there is notably less current literature. LeResche (1966) (*in* Canfield et al. 1999) reported reactions ranging from "flight, to drifting away, to disinterest". Moose often appear unalert because frequently they can be approached rather closely without fleeing. However, even then, an ear may be raised as a sign of alertness (Silverberg et al. 2003). A number of authors in descriptive accounts note that viewing of moose does not seem to cause alarm, but that loud, unexpected noises are often disruptive (Denniston 1956 *in* Canfield et al. 1999). A car horn or door slam could cause a flight of 500 yards (450 meters), but noise of passing traffic elicited no visible response during one study (Cobus 1972 *in* Silverberg et al. 2003). Viewers with moderate or low voices caused little response by moose, but moose showed alarm at loud voices (Silverberg et al. 2003). Distance at which moose respond to approaching viewers varies by individuals, season and situation. In Yellowstone National Park during fall hunting season moose fled when approached within 200-300 yards (200-300 meters), but in May and June a cow-calf pair could be approached to within 30-70 yards (30-65 meters)(Altmann 1958 *in* Silverberg 2003).

Moose have been found to respond negatively to snowmobiles and cross-country skiers. In the Greys River Valley of Wyoming, moose that bedded within 300 meters (1000 feet) and fed within 150 meters (500 feet) of passing snowmobiles changed their behavior in response to the disturbance (Colescottt and Gillingham 1998). At Elk Island National Park, Alberta, moose moved away from heavily-used cross-country ski trails, resulting in a shift in the general over-winter distribution of moose during winter (elk also moved away from ski trails on a daily basis but their general distribution was not affected) (Ferguson et al. 1982).

As a high-profile wildlife species, moose habituate to wildlife viewing and human presence (McMillan 1954). In places where moose attract a fair amount of attention, wildlife education can be an important tool in allowing visitors to have a positive wildlife viewing experience, while also learning how noise levels and approaching moose can be detrimental to their experience and to wildlife (Silverberg et al. 2003).

Management considerations:
Trails and other routes should not separate bedding and feeding areas. Trails should be routed away from key foraging areas (e.g. drainage heads, mesic areas) (Canfield et al. 1999).

BIRDS

Human intrusion can affect bird behavior, distribution, habitat use, reproduction and survival (Knight and Gutzwiller 1995). Habitat loss and fragmentation are the major factors affecting bird populations at landscape scales, but human activity is a primary stressor of bird populations at local scales (Schlesinger 2008). There is a wealth of studies on the impacts of various forms of human disturbance on bird communities in general, however, detailed information on individual species is relatively rare.

In a study in the Netherlands, low-impact activities (hiking and biking) were found to negatively affect breeding bird densities for 8 of 13 species (van der Zande et al. 1984). A review of impacts of noncomsumptive recreation on wildlife showed that 77 of 166 studies found negative effects on birds (Boyle and Samson 1985).

Birdwatching, photography, research, and various forms of recreation can cause an increase in risk of nest predation of songbirds. In subalpine forests of the Rocky Mountains, Gutzwiller et al. (2002) found that low-impact, repeated human intrusions (by a solitary hiker) into an area increased the number of gray jays, and thus also likely increased levels of nest predation on other bird species. High-use recreation areas, such as campgrounds and picnic areas, often have higher levels of nest predators as well, drawn by food and garbage left behind by visitors (Delap and Knight 2004). Horses can attract brown-headed cowbirds and potential predators, especially if a stable or corral is nearby (U.S. Fish and Wildlife Service 2002).

High visitor use of daytime recreation areas and campgrounds can negatively impact local bird populations in a variety of ways. Often such areas have reduced habitat structure and complexity, which can lead to a decline in species diversity and richness (Hammitt and Cole 1987). Generalist species may become more common and specialist species more rare. Reduced shrub and tree densities, woody debris, and litter depth in campgrounds cause ground, shrub, and small tree nesters to decline (Blakesley and Reese 1988).

In response to disturbance, some birds may nest higher in the tree canopy, which can lead to problems with thermoregulation and wind damage to nests (Gutzwiller et al. 1998). Birds may also abandon nests or young. Human disturbance may lead to disruption of feeding patterns and parental attentiveness, potentially increasing risk of nest predation and additional environmental stress on eggs or young (Knight and Cole 1995).

Recreation impacts on bird species are summarized in Table 7.

Table 7. Detailed information on potential impacts by recreation type for birds.

	Snowmobiles	Skiing	Hiking	Biking	Horseback riding	Human presence/ Wildlife observation	Trails	Developed recreation sites
Goshawk	No specific information, but impact of passing recreationists is likely minimal. To reduce nest site disturbance a spatial buffer of 400-500 meters is recommended (Jones 1979 *in* Gaines et al 2003).						Trails near nests may increase vulnerability of nestlings taken for falconry (Boal et al 2005, Erdman et al 1998).	Limited information but are documented cases of camping near nests leading to nest failure (Speisert 1992 *in* Squires and Reynolds 1997). Goshawks nest further from human features (habitations and roads) than otherwise expected (Bosakowski and Speiser 1987).
Boreal owl	No specific information, but are considered fairly tolerant of human disturbance (ADFG 1994).							Are documented existing within housing developments (ADFG 1994).
Pileated woodpecker	No specific information, but are considered fairly tolerant of human disturbance. Some birds may change roost sites if disturbed and may aggressively defend nest. (Bull and Jackson 1995).						Firewood cutting near trails with motorized access can result in loss of snags, a key habitat component (Hamann et al 1999).	No specific information, but are considered fairly tolerant of human disturbance. Some birds may change roost sites if disturbed and may aggressively defend nest.(Bull and Jackson 1995).
Black-backed woodpecker	No specific information, but are considered fairly tolerant of human disturbance. May aggressively defend nest. (Dixon and Saab 2000).						Firewood cutting near trails with motorized access can result in loss of snags, a key habitat component (Hamann et al 1999).	No specific information, but are considered fairly tolerant of human disturbance. May aggressively defend nest. (Dixon and Saab 2000).

(continued on next page)

(Table 7 continued)

	Snowmobiles	Skiing	Hiking	Biking	Horseback riding	Human presence/ Wildlife observation	Trails	Developed recreation sites
Dusky grouse	No specific information. "Increasing recreational inroads into montane areas and urbanization remain a threat to dusky grouse" Zwickel and Bendell (2005).							
Brown creeper	No information.						Fragmenting effects of trails can lead to increases in nest predation (Hickman 1990, Miller & Hobbs 2000). Trail construction can result in loss of snags and other important habitat components.	No information
Winter wren	No specific information but are considered fairly tolerant of human disturbance (Hejl et al 2002a).						Fragmenting effects of trails can lead to increases in nest predation (Hickman 1990, Miller & Hobbs 2000). Trail construction can result in loss of snags and other important habitat components.	No information.
Olive-sided flycatcher	No specific information but are considered fairly tolerant of human disturbance (Hejl et al 2002b).						Trail construction can result in loss of snags and other important habitat components.	No information.

Goshawk

Northern goshawks occur throughout much of the northern United States. They occupy coniferous and mixed forests and are associated with mature and old growth forest structures. Goshawks are listed federally as a species of concern, and are candidates for Washington Species of Concern listing.

Evidence suggests that human disturbance can have impacts on raptor species (Andersen et al. 2005, Richardson and Miller 1997). However, little information exists on recreation impacts on goshawks. Squires and Reynolds (1997) state goshawk "winter habitat use is so poorly understood that potential impacts of human activities cannot be assessed." Nesting and post-fledgling periods are the most critical times for evaluating human disturbance to goshawks (Gaines et al. 2003).

Most of the disturbance-based literature for goshawks relates to timber harvest in home ranges and near nest sites, and discusses potential effects from habitat loss (Mahon and Doyle 2005) and increased competition from more open-forest raptors, such as red-tailed hawks and great horned owls (Crocker-Bedford 1990). As opposed to timber harvest, the amount of habitat in a goshawk's home range directly lost from recreation trail construction is likely to be minimal.

Information from Squires and Reynolds (1997) suggests that short-duration human disturbance (such as might be associated with passing hikers or skiers) is likely to be minimal and have little long-term impact on nesting birds. They note that short disturbances associated with goshawk research at nest sites after young have hatched, does not cause desertion. However, camping near nests has caused failures (n = 2, Speiser 1992 *in* Squires and Reynolds 1997).

Although we could find no literature relevant to goshawks and snowmobiles, goshawks appeared insensitive to logging truck noise at >400 m. from nest sites (Grubb et al. 1998), and thus may potentially be similarly insensitive to be snowmobile noise at equivalent distances.

There are concerns that increased access to goshawk nest sites from roads and trails may lead to greater mortality and loss of nestling goshawks taken for falconry (legal and illegal). Squires and Reynolds (1997) state that although the impact of falconry on wild populations is unknown, they believe it to be minimal. However, in Minnesota, human persecution accounted for 22% of goshawk mortality (of 14 monitored birds killed during a 3 year study) (Boal et al. 2005). In Wisconsin, falconers accounted for 5% loss from nests (Erdman et al. 1998). Estimated sustainable harvest rates for goshawks are 5% of annual production (Millsap and Allen 2006).

Management considerations

Impacts of human activities on raptors are often reduced with temporal or spatial buffer zones (Richardson and Miller 1997). "Management agencies usually attempt to reduce disturbance during the nesting period by delineating protected areas around nest trees" (Reynolds 1983). Jones (1979) (*in* Gaines et al. 2003) recommended a spatial buffer of 400-500 meters (up to 1600 feet) to protect goshawk nests from human disturbance, from March 1st to September 30th.

Boreal owl

Boreal owls occur year-round in high elevation mature and old growth coniferous forests in Canada, only in the last 40 years extending their distribution south into the US, where breeding populations have been reported in many northeastern and western states (Heinrich et al. 1999). Boreal owls are not listed federally, and are a state monitor species in Washington.

Very little information exists on boreal owls in relation to human disturbance. We were unable to find any reference in the scientific literature to impacts on boreal owls from recreation. Hayward and Hayward (1993) note that disturbance, shooting, trapping, and pesticides are not reported to have important impacts on boreal owls. As a species associated with mature and older forests, indirect effects from timber harvest are probably the most significant human-related influence on the species. The Alaska Department of Fish and Game describes boreal owls as "fairly tolerant of disturbance" and states they have been found "existing within housing developments, provided the natural character of the boreal forest is retained" (ADFG 1994).

Pileated woodpecker and Black-backed woodpecker

Pileated woodpeckers and black-backed woodpeckers are both primary cavity excavators, both dependent on large, standing snags for nest sites. Pileated woodpeckers are associated with mature and old-growth coniferous forest and black-backed woodpeckers with recent fires, burns, or other large-scale natural disturbances in coniferous forests. Loss of habitat associated with timber harvest for pileateds, and fire suppression and postfire salvage logging for black-backeds, are the greatest risk factors for these species (Bull and Jackson 1995, Dixon and Saab 2000). They are not listed federally, and are both state candidate species in Washington State.

In general, little information exists regarding recreation impact on woodpeckers. However, recreational activity affecting woodpeckers is most likely to be sporadic and not focused around nest sites (Hamann et al. 1999). Given the notably greater habitat concerns for these species, recreational impacts are unlikely to be a limiting factor.

Accounts occurring in the literature vary as to the reaction of woodpeckers to human disturbance. For example, Short (1974) (*in* Dixon and Saab 2000) described black-backed woodpeckers aggressively defending their nest tree during his repeated observations. Bent (1939) (*in* Hamann et al. 1999) described several species of woodpeckers as “not shy” in human presence. Bull and Jackson (1995) describe pileated woodpeckers as generally “tolerant” of human activity near nests and roosts, but note that some pileated woodpeckers will change roost trees if disturbed. Hoyt (1957) (*in* Bull and Jackson 1995) reported being attacked by a male pileated woodpecker at a nest site.

One potential indirect factor that may negatively affect woodpeckers is legal or illegal firewood cutting associated with motorized access on trails. Woodcutters often select disproportionately for large diameter standing snags, which otherwise could provide high value habitat for cavity nesting species (Hamann et al. 1999). Likewise, valuable snags that occur near campsites, trails, and other developed recreation areas are sometimes identified as potential hazards by land management agencies and are cut down.

Management considerations

Environmental education on the value of snags for cavity-dependent species, targeted at woodcutters, may help to reduce loss of these important habitat features. Frissell (1994) offers management guidelines to reduce impacts of woodcutting on cavity nesting species. These include, avoid cutting snags that already show evidence of bird use, leave all snags larger than 20 inches dbh, leave snags with broken tops, avoid cutting trees that show evidence of heart rot, and avoid cutting western larch, ponderosa pine, and black cottonwood.

Dusky grouse

Dusky grouse occur in western North America. They inhabit open coniferous forests with deciduous trees and shrubs. Dusky grouse utilize open coniferous forests edges and aspen groves for breeding and summer foraging, and denser high elevation coniferous forests during the winter (Zwickel and Bendell 2005). Populations are generally considered healthy. They are hunted and managed as a game bird in the state of Washington, and are not listed at the federal or state level.

Although we could find no empirical data on recreation impacts on dusky grouse, Zwickel and Bendell (2005) state that “increasing recreational inroads into montane areas and urbanization remain a threat to dusky grouse”.

Brown creeper, Winter wren and Olive-sided flycatcher

Brown creepers, winter wrens, and olive-sided flycatchers are fairly common to common songbirds occurring in Washington state and other portions of North America. Brown creepers and winter wrens are found in the Selkirk Mountains throughout the year, while olive-sided flycatchers migrate to Central and South America for winter. None of these three species is listed at the state or federal level.

Brown creepers and winter wrens are forest interior species, typically associated with mature and old-growth forest structures. Conservation concerns for these species include loss of habitat and forest fragmentation. Both species forage on the ground or near the ground (winter wrens primarily on coarse woody debris on the forest floor and brown creepers on tree trunks and branches). This makes them potentially more susceptible to disturbance from human activities. Olive-sided flycatchers, on the other hand, are an edge species and fragmentation provides them greater foraging opportunities. They also perch high in the forest canopy and so are less likely to be affected by ground-level disturbances.

Few studies address impacts of trails or recreational activities on individual songbirds. However, a fair amount of research has been directed toward assessing the impacts of human disturbance and/or recreation on songbird behaviors and overall density and diversity of songbirds. For this reason, these 3 songbirds are grouped under a single heading in this report, but with discussion of individual species and/or groups (e.g. interior or edge species) as information is available.

Habitat loss is by far the most important conservation concern for all three species. Although recreation-driven projects may contribute to some types of habitat loss, these are likely relatively minor compared to impacts on the species from timber harvest and wildfire management. Potential recreation-related impacts on the three species include direct human disturbance of birds, forest fragmentation resulting from roads and recreational trails, loss of key habitat structural components associated with development of recreational sites (trails, roads, and other features), and nest predation.

Several studies have investigated impacts of human presence on songbirds and found negative responses. Gutzwiller et al. (1997) detected curtailments of singing activity in some species in the presence of hikers and thought this may reduce breeding activity and quality of those sites for young. In a later paper (Gutzwiller et al. 1998) describe a lower tolerance of humans by more conspicuous species, and birds that were active nearer the ground (such as winter wrens). In Colorado coniferous forests, Riffell et al. (1996) found declines in richness and abundance of core species related to human intrusions. Aitchison (1977) (*in* Hamann et al. 1999) found density and diversity of songbirds was reduced in open campgrounds.

Little information is available on the effects of direct observation (for recreation or research) on songbirds. However, Hejl et al. (2002a) write that winter wrens appear relatively tolerant of human observation, with adult males allowing humans as close as 15 meters (50 feet) and females remaining on the nest up to a distance of only 0-5 meters (<16 feet), depending on the individual. Researchers observing nests over time and even removing (and returning) nestlings for banding did not affect nest success. No information was available for brown creepers. Olive-sided flycatchers are "generally unaffected" by observation although banding and other research activities at nests have resulted in nest failure and premature fledging (Altman and Sallabanks 2000).

Forest fragmentation is a primary concern for winter wrens and brown creepers, although olive-sided flycatchers may benefit. Fragmentation effects of roads are well known, but much less attention is given to similar impacts from recreational trails. Road corridors can create significant breaks in continuous forest habitat, reducing use by forest interior species. Winter wrens and brown creepers occur more commonly in larger forest patches and therefore are likely to be negatively impacted by roads that fragment habitat (Hutto 1995, Keller and Anderson 1992). Road corridors open opportunities for nest predators and brown-headed cowbirds (nest parasites) and reduce size of interior forest patches. In the northern Rockies, Hutto (1995) noted that brown creepers and golden-crowned kinglets (both interior forest species) were twice as likely to occur 100 meters (300 feet) or more away from a road than adjacent to a road.

Fragmenting effects are not limited to wide road corridors and powerlines, however. Narrow corridors associated with smaller roads and nature trails may have similar impacts. Rich et al. (1994) quantified songbird responses to various corridor widths and found corridors as narrow as 8 meters (25 feet) produced forest fragmentation effects, attracting cowbirds and nest predators to the corridor and adjacent interior forest. In Illinois, Hickman (1990) found nest predators and cowbirds attracted to trail corridors only 2-3 meters (4-6 feet) wide. Miller and Hobbs (2000) also note that predation of songbird nests was greater closer to forested hiking trails. Another study found bird composition and abundance of songbirds was altered adjacent to trails in pine forests of Colorado (Miller et al. 1998). Generalist species were more abundant along trails and specialist species were less common. Nest predation was higher along trails, although rate of brood parasitism was not. For species sensitive to trails, the zone of influence appeared to be about 75 meters, but was up to 100 meters for Townsend's Solitaires (250-330 feet).

In addition to increased fragmentation, trail construction sometimes results in the loss of important habitat structural components. Snags are used by olive-sided flycatchers as perches and by creepers for foraging and nesting. These are often considered hazards when adjacent to trails and higher use recreation areas, and are cut down.

Management considerations

Although little empirical data exists on recreation impacts specifically on winter wrens, brown creepers, and olive-sided flycatchers, it seems clear that even relatively unobtrusive recreation, such as hiking and hiking trails, can have impacts on songbirds. For this reason, concentrating recreation and associated trails in currently used areas is recommended rather than spreading use to relatively unimpacted areas (van der Zande et al. 1984).

SMALL MAMMALS

Recreation impacts on small mammals are summarized in Table 8.

Table 8. Detailed information on potential impacts by recreation type for small mammals.

	Snowmobiles	Skiing	Hiking	Biking	Horseback riding	Human presence/ Wildlife observation	Trails	Developed recreation sites	Other
Pika	No information.	No information.	Plausible impacts (but not discussed in scientific literature) are: 1) may disturb summer foraging behavior and 2) may damage fragile high-elevation meadows used for foraging.				No information.	No information.	Negative association between distance to primary roads and persistence of pika populations (Beever et al. 2003).
Pygmy shrew	Snow compaction from snowmobiles disturbs use of subnivian environments and causes mortality (Bury 1978 *in* Hickman et al. 1999).	No information.	Impacts of heavy recreation use near lake/wet edges damage habitat.					No information.	Roads increase direct mortality. Roads are avoided and limit dispersal (McGregor et al. 2008).
Hoary bat	No information.								Motorized recreation at night may interfere with echolocation (Hickman et al. 1999).
Silver-haired bat	No information.								Motorized recreation at night may interfere with echolocation (Hickman et al. 1999).

Pika

Pikas are found at high elevations on rocky talus slopes of western mountain ranges. They forage on grasses and alpine vegetation in adjacent meadows. Pikas are currently under review for protection under the endangered species act due to concerns over climate change, the primary threat to their persistence (Wolf et al. 2007). Impacts from human recreation are likely comparatively minor, but may create additional constraints on already stressed populations.

Recreational use of high elevation environments continues to increase, and the alpine meadows used by both hikers in summer and by foraging pikas are fragile environments. Hikers may trample vegetation, and human presence may disrupt foraging of pikas. Although none of the literature found for pikas discusses human impacts on foraging, it seems highly plausible that human presence may cause a disruption, as was found to be the case with marmots (*Marmota marmota)* (Mainini et al. 1993). Foraging opportunities for pikas are already becoming limited due to climate change and their extreme sensitivity to heat. (Wolf et al. 2007). Pikas cannot survive out of their burrows at temperatures above 80 - 85 degrees. Yet, because they have high energetic demands relative to other montane mammals, they make up to 27 trips per hour to collect vegetation for immediate consumption and winter storage (Wolf et al. 2007). Thus, any potential disruption to foraging activity caused by human presence is likely to negatively impact the species.

Although roads are less common at the higher elevations typical of pika habitats, there still appears to be some negative effects of roads on pika persistence. A study in the Great Basin examined 25 historical populations of pikas and attempted to tease out the relative natural and anthropogenic factors influencing population persistence (Beever et al. 2003). Of a multitude of potential factors, their best model for persistence of pika populations contained 3 variables: area of habitat in the mountain range, maximum elevation of talus habitat, and distance to primary roads.

Management considerations:

Due to the fragility of alpine meadows and their importance for pika forage in summer, recreation should be directed toward other, less fragile environments.

Pygmy shrew

Pygmy shrews are distributed across the boreal regions of the United States and Canada with disjunct populations in Colorado/Wyoming and the Appalachians. They live along forested and wetland edges. Pygmy shrews are active beneath the snow all winter, making use of subnivian environments for thermal regulation and protection (Wund 2000). They have high-energy demands and must consume large amounts of high-energy foods for survival (Beauvais and McCumber 2006). Pygmy shrews are not listed federally, but in Washington they are a state monitor species.

Very little information exists on pygmy shrews and even less on potential impacts of recreation. Pygmy shrews are a particularly vulnerable species to all types of disturbances due to their short life span, limited reproduction (1-2 year lifespan, breeding only once at 10 months), small populations, and extremely limited dispersal abilities (Beauvais and McCumber 2006). The largest anthropogenic impacts on pygmy shrews come from habitat alteration and livestock grazing. Heavy recreation use near lake/wet edges may damage habitat.

Recreation-related factors affecting pygmy shrews are snowmobile use and presence of roads. Roadbeds and adjacent vegetation and soils are often drier than the surrounding environment. Roads are an impediment to the movement of many small mammals (McGregor et al. 2008) and likely restrict pygmy shrews. Traffic from roads also can result in direct mortality of small mammals. Avoidance of roads by some small mammals appears to be based on the presence of roads themselves, regardless of traffic levels (McGregor et al. 2008). The extent to which trails may create similar restrictions depends on the size, type, and location of trails.

Snow compaction from snowmobiles alters subnivian microclimates, reducing insulation and passage of O_2 and CO_2. This creates additional stress on the systems of small mammals in winter, increasing risk of mortality (Schmid 1971 *in* Boyle and Samson 1985). Bury (1978) (*in* Hickman et al. 1999) states that "… snowmobiles crush small mammals that inhabit the subnivian space between snow and ground". Pygmy shrews are most vulnerable to snow compaction near wetland habitats, open forests and wet areas adjacent to forest (Beauvais and McCumber 2006).

Management considerations:

Given the lack of information of recreation impacts on small mammals in general, and pygmy shrews in particular, management guidelines should be conservative. Snowmobile use and intense recreational activities should be limited near forest/wetland edges. Activities, such as trail development, that might alter the hydrology of wet areas should be avoided (Hickman et al. 1999).

Silver-haired bat

Silver-haired bats are a forest species, roosting on or in trees. Forest structural components of roost sites are the primary emphasis of research and conservation in the Northwest. The IUCN lists this species as one of "least concern" due to its tolerance to some degree of habitat modification and other factors (Arroyo-Cabrales et al. 2008). They are not listed at the federal or Washington State levels.

We found no references to impacts on the species from any form of human disturbance, other than as related to changes in forest structure through forest management practices (Campbell et al. 1996). Hickman et al. (1999) speculate that motorized recreation at night may interfere with echolocation of bats.

Hoary bat

Hoary bats are the most widespread of all American bat species. They roost in the foliage of trees, keeping themselves well hidden, and thus are typically not encountered by humans. They have neither federal nor Washington State status. We could find no references to impacts on the species from recreation. The Organization for Bat Conservation notes that occasionally if there is a disturbance at a site to a mother and young, the mother will move the pups from one tree to another, but the type of disturbance is not specified. There are reports of mother hoary bats grounded with her young clinging to her, unable to fly with the extra weight (Organization for Bat Conservation 2009). Hickman et al. (1999) speculate that motorized recreation at night may interfere with echolocation of bats. The primary disturbance type for hoary bats discussed in the literature is mortality from wind turbines (Arnett et al. 2008).

OTHER SPECIES

Western toad and Compton tortoiseshell butterfly are the “other species” assessed. Little information exists for either species, and no information specifically related to recreation impacts was found. A more general search of “human” or “recreation” paired with “frogs or toads” and “butterflies” for each of the species, respectively, provided some information potentially relevant to Western toads, but none relevant to the Compton tortoiseshell butterfly. Recreation impacts on Western toads and the Compton tortoiseshell butterfly are summarized in Table 9.

Table 9. Detailed information on potential impacts by recreation type for other species.

	Snow mobiles	Skiing	Hik-ing	Biking	Horse back riding	Human presence/ Wildlife observation	Trails	Developed recreation sites	Other
Western toad	No information.	No information.	No information on specific recreation impacts in literature. However, heavy recreational use by horsepackers, backpackers, and others near water edges, leading to more bare ground, has been related to a decline in anuran species (Vinson 1998)				No information on specific recreation impacts in literature. However, trails and roads near wetlands can alter drainage patterns, negatively impacting wildlife habitat.	No information on specific recreation impacts in literature. However, campgrounds along lakes associated with heavy use by horsepackers/ backpackers leads to more bare ground and has been associated with decline in anuran species (Vinson 1998)	Potent-ial direct mortal-ity from motor-ized vehicles on roads.
Compton tortoise-shell butterfly	No information on specific recreation impacts in scientific literature. Heavy recreational use of meadows and other open habitats of the Compton tortoiseshell butterfly however, could degrade habitat by trampling vegetation and increasing presence of invasive weeds.								

Western toad

Western toads occur in the western United States and western Canada. They are found in a variety of habitats, occurring near waters' edge in spring and summer and in more terrestrial habitats later in the year (AmphibiaWeb 2009). Western toad populations are declining in many areas. They are listed federally as a species of concern, and are state candidates in Washington State. Suspected factors contributing to their decline include habitat degradation and destruction, introduction of aquatic predators (fish stocking in lakes), direct mortality of migrating toads on roads, spread of diseases, acid and mineral pollution from mine water drainage, and climate change effects, including changing temperatures, water levels and increasing ultraviolet radiation (AmphibiaWeb 2009).

Little information exists on recreation impacts on amphibians and none was found on western toads specifically. However, some impacts reported for other species or on anurans in general likely relate to western toads. In the Sierra Nevada, Vinson (1998) found that anurans were less abundant at high elevation lakes heavily used by horsepackers and backpackers. These lakesides contained greater areas of bare ground than lakesides receiving less recreational use.

Trails and roads near wetland areas can divert or alter surface water flows, potentially negatively impacting habitat for anuran species.

Compton tortoiseshell butterfly

The Compton tortoiseshell butterfly is widely distributed, occurring in Europe, Asia, and much of North America. In North America, it is found from Alaska and Labrador south to West Virginia and Utah Larval food plants include birch, willow and aspen species. Adults utilize open habitats, including meadows, forest glades, forest clearings, and riparian areas. They are sometimes found in aggregations around wet spots on the ground (Gillam 1956). They are not listed federally, but are a state monitor species in Washington State.

No information was available on recreation impacts on the Compton tortoiseshell butterfly or butterflies in general, using Web of Science searches. However, the meadows and other open habitats of the Compton tortoiseshell butterfly are attractive places for many recreationists, including horseback riders, hikers, campers, and mountain bikers. Concentrated use of these habitats may result in trampling of the vegetation and potential increases of invasive weed species. The extent to which such impacts affect the Compton tortoiseshell butterfly are unknown.

Conclusion

This report has evaluated recreational impacts on a wide range of taxa and found a similarly wide range of direct and indirect effects, both positive and negative, on the 21 focal species of Mt. Spokane State Park. In common, however, is that even for species with the greatest research (wide-ranging carnivores and ungulates), an inadequate amount of information exists on recreational effects. Anecdotal information is available in many older natural history studies. This is often strongly context dependent, however, and many cases of contradictory evidence are presented even for relatively well-studied interactions, such as white-tailed deer response to snowmobiles. Factors such as animal condition, environmental context (e.g. open vs. forested habitat), group size, season, etc. can make significant differences in how animals respond to various recreational disturbances.

Only recently, driven by the strong current and projected increases in recreational pressure on natural areas, are studies being designed specifically to evaluate impacts from recreation on species and their habitats. Elevated heart rates, glucocorticoid responses, and other behaviors such as alertness and flight are short term responses exhibited by wildlife to recreation. Long-term impacts of such responses on individuals, populations, and communities are not well understood. Techniques for the study of human stressors on wildlife are still being developed and evaluated, with a focus on repeatability of results, and improving translation of behavior and other indicators of disturbance to predictability of species presence, absence, and population viability (Tarlow and Blumstein 2007, Taylor and Knight 2003b).

Recent studies indicate that recreational impacts on some species and their habitats may be notably stronger than previously suspected. For example, Reed and Merelender (2008) found that "dispersed, nonmotorized recreation led to a five-fold decline in the density of native carnivores and a substantial shift in community composition from native to nonnative species" in northern California. In Antelope Island State Park, Utah, Taylor and Knight (2003a) estimated that "7% of the island was potentially unsuitable for wildlife due to disturbance from recreation."

Although recreation impacts on wildlife appear notable in some cases, visitor perceptions do not appear to be in line with their level of influence (Flather and Cordell 1995). In a survey of recreationists, only 50% felt that recreation had negative impacts on wildlife. Different recreation groups (e.g. horseback riders, bikers, hikers, etc.) generally considered their own form of recreation relatively benign compared to negative impacts from other recreation groups. Additionally, most respondents perceived it was acceptable to approach wildlife much closer than data suggested.

Without adequate understanding of the potential negative impacts of recreation on wildlife, visitors are less likely to comply with regulations or support measures designed to protect species and their habitats (Taylor and Knight 2003a). Educational campaigns can have positive impacts on visitor behavior, in turn reducing stress on wildlife (Silverberg et al 2003). Klein (1993) found that visitors who interacted with staff at a wildlife refuge were less likely to disturb wildlife than recreationists who did not.

Despite the complexities of recreation-wildlife interactions, some common threads exist that land managers can use to form the basis of recreational planning, reducing potential negative impacts on a variety of species. As just mentioned, educational efforts can be effective in reducing visitor stress on wildlife and fostering a sense of stewardship. Many species are displaced or avoid areas of human use. The more dispersed trails and other recreational infrastructure is, the greater the overall area impacted. Use of recreational zoning and concentration of trails in particular areas can help minimize reductions in species' use of otherwise suitable habitat. Trails should be designed to avoid special habitats (e.g. fragile alpine meadows, seeps, etc.) and separation of critical habitats, such as bedding/resting and foraging areas of ungulates. Topography can be used where possible, to serve as visual and sound barriers. Temporary closures or other visitor restrictions may be necessary at some locations (denning, rendezvous sites, winter ranges) during particularly vulnerable times for some species. Buffers applied to such closures should use conservative distance estimates. Restrictions may need to be placed on domestic dogs, restricting them from critical areas, and enforcing leash regulations. Lastly, strong evidence exists for many species that predictability is an important component in the level of disturbance they experience from recreationists. Off-trail activities are inherently unpredictable and cause greater stress for wildlife than on-trail activities. Education can provide an important role in discouraging off-trail recreational use.

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