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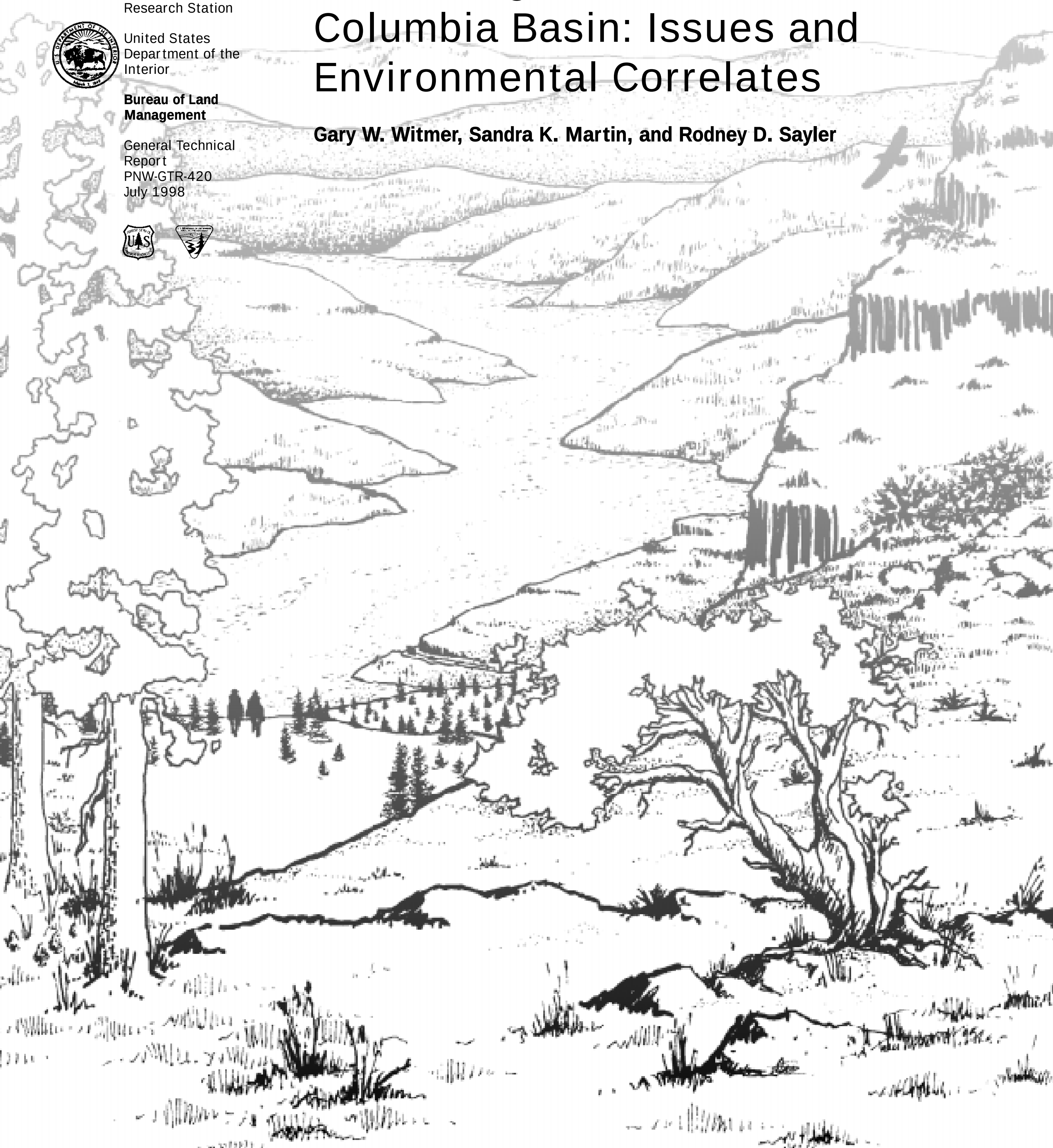
Forest Carnivore Conservation and Management in the Interior Columbia Basin: Issues and Environmental Correlates

Gary W. Witmer, Sandra K. Martin, and Rodney D. Sayler



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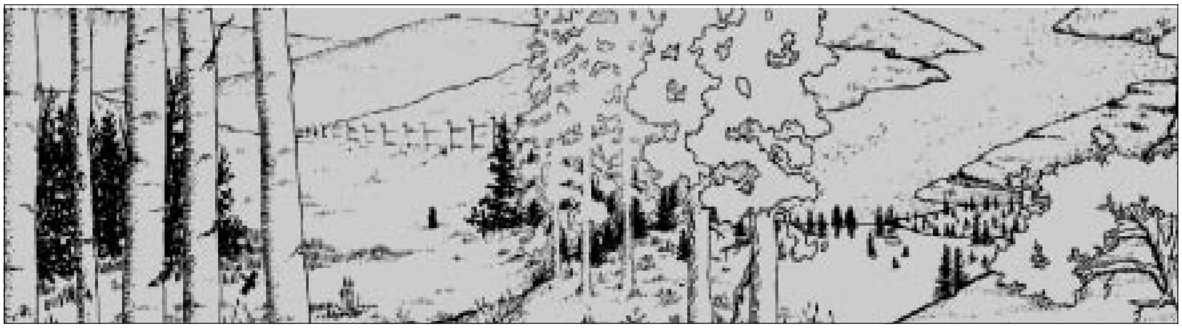

Forest Carnivore Conservation and Management in the Interior Columbia Basin: Issues and Environmental Correlates

Gary W. Witmer, Sandra K. Martin, and Rodney D. Sayler

Interior Columbia Basin Ecosytem Management Project: Scientific Assessment

Thomas M. Quigley, Editor

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Abstract

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Forest carnivores in the Pacific Northwest include 11 medium to large-sized mammalian species of canids, felids, mustelids, and ursids. These carnivores have widely differing status in the region, with some harvested in regulated furbearer seasons, some taken for depredations, and some protected because of rarity. Most large carnivores have declined in numbers or range from human encroachment, loss or modification of forest habitat, accidental deaths (e.g., mortality from vehicles), illegal kills, and our inability to adequately monitor and protect populations. Efforts to reverse these trends include new approaches to reduce conflicts with humans, research to better define habitat needs, formation of expert carnivore working groups, and use of Geographic Information System models to predict specific impacts of habitat modifications. Long-term preservation of large carnivores in the region is problematic unless we reduce forest fragmentation and conflicts with humans and improve our ability to quantitatively integrate population dynamics with landscape level habitat requirements.

Keywords: Coyote, gray wolf, bobcat, lynx, mountain lion, fisher, marten, river otter, wolverine, grizzly bear, black bear, conservation, management, carnivores, late successional forest, wilderness, roads, disturbance, fragmentation, conservation biology, geographic information systems, forest management, animal damage.

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Introduction

Carnivores were selected for specific attention by the Interagency Interior Columbia Basin Ecosystem Management Team because of viability concerns. Carnivores are key species in wildlife communities; they provide, in their role as top predators in the trophic webs, a gauge of the health of entire systems because of their ultimate dependence on other populations and processes. Carnivore interactions with prey populations create dynamics crucial to the balance of these systems and their long-term sustainability. Forest carnivores also are vulnerable to habitat alteration and exploitation and have a long and complex historical relation with humans (Clark et al. 1996c, Kellert et al. 1996). These species are variously managed as harvested furbearers, unprotected depredatory animals, or protected or endangered species (Keiter and Locke 1996). If the needs of large, far-ranging carnivores are met, often the needs of many more species lower on the trophic scale will also be met—the so-called umbrella effect (Noss et al. 1996, Peterson 1988). Some large carnivores present special problems to managers because of depredation, public safety issues, and competition with other wildlife resources. Several carnivores in the Western United States have declined dramatically in the last century and a half and are listed as threatened or endangered species, or are considered sensitive by land management agencies (Noss et al. 1996). Portions of the Pacific Northwest hold the largest wildland areas in North America with most carnivore species still present (Clark et al. 1996c).

We do not know nearly enough about forest carnivore species to adequately provide for their needs and eliminate conflicts with humans. These species are mostly far ranging, elusive, shy and inconspicuous, occur in low densities, and are active mainly at night (Kucera and Zielinski 1995). We know little about their status and distribution, partly because they currently are not harvested at anywhere near historical levels. This makes the study and management of forest carnivores problematic at best. The numerous research needs for these species are detailed by many investigators (Clark et al. 1996b, Kucera and Zielinski 1995, Peterson 1988, Quigley and Hornocker 1992, Ruggiero et al. 1994).

As the process of ecosystem management continues, specific land management issues must be identified and considered as they affect conservation and viability of wildlife. Some of the tools that will be needed for assessment, modeling, and monitoring include Geographic Information Systems (GIS) and associated databases. Attributes relevant to the ecology of selected species that can be identified from satellite imagery used to develop existing USDA Forest Service GIS databases need to be identified. Those attributes that should be available—but not yet are—also should be identified.

Eleven medium- to large-sized carnivore species present in the interior Columbia basin (referred to throughout as “the basin”) were selected by the Interior Columbia Basin Ecosystem Management Team for the identification of issues surrounding conservation and population viability. The species included canids (coyote, gray wolf), felids (bobcat, lynx, mountain lion), mustelids (fisher, marten, river otter, wolverine), and ursids (black bear, grizzly bear). The current state of scientific knowledge of the ecology and management of each species was surveyed through review of recent literature. Issues surrounding conservation of the species in the region were identified by (1) a panel of experts that convened briefly in December 1994 to address the topic;[1] (2) current conservation assessments, reviews and scientific literature; (3) our personal knowledge and background; and (4) outside review of this document. Key environmental correlates were identified as factors that affect the distribution or viability of each species. Those correlates that could be identified on currently available GIS were listed with the relevant conservation issue. Additionally, correlates that probably are important to viability of the species, but which cannot currently be tracked on GIS, were distinguished. Several conservation issues intersected the ecology of more than one species of those evaluated,

[1] The panel included Keith Aubry, USDA Forest Service, Olympia, WA; Vivian Banci, Ministry of Environment, Victoria, BC; Gary Koehler, Washington Department of Fish and Wildlife, Olympia, WA; Len Ruggiero, USDA Forest Service, Missoula MT; and John Weaver, Missoula, MT.

and these are identified and discussed. The continuing need for more and better information, and the tools to gather that information, is notable, particularly for many of these forest carnivore species. Many of these species are rare, difficult to census and study, and yet very important in their roles in the function of ecosystems and their values to humans.

Coyote (*Canis latrans*)

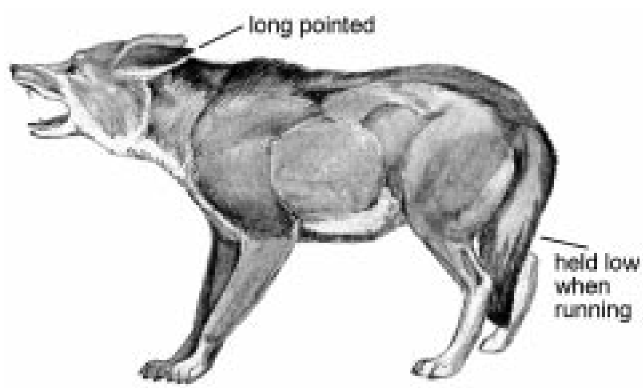
Ecology

Coyotes occur throughout most of North America, including the entire interior Columbia basin (appendix A). They use almost all types of habitats where prey are available (Bekoff 1982, Voight and Berg 1987). Their range and densities have increased over historical levels because of increased forest clearing, agriculture, and livestock production, and the control of wolves (*Canis lupus*) and other more specialized carnivores (Toweill and Anthony 1988, Voight and Berg 1987, Witmer and deCalesta 1986). Their range is limited in the far north by snow and arctic conditions; to the south, their range has extended in recent dacades to Panama in Central America.

Home range sizes are quite variable, but average from 4-12 km^2 (Bekoff 1982, Voight and Berg 1987). Coyotes are social animals, and groups will actively defend their territory from other coyotes. Coyotes can disperse over large distances, often 100+ km (Harrison 1992).

Coyotes are omnivores and their diet varies by area and season in relation to prey, carrion, and fruit availability (Bekoff 1982, Voight and Berg 1987). Lagomorphs and rodents typically comprise a large part of the diet, but fruit in late summer and fall, carrion in winter and spring, and young ungulates in spring through early summer can be significant components. Coyotes readily take livestock as prey, and substantial coyote control efforts to reduce depredations continue in the Western States (USDA 1994). Coyote densities range widely (up to $2/km^2$) and are closely related to prey abundance (Bowen 1982, Clark 1972, Mills and Knowlton 1991, Nellis and Keith 1976).

Coyotes are habitat generalists and occur in most habitats, especially where there is a mix of cover and open areas supporting abundant and diverse prey (Bekoff 1982, Voight and Berg 1987). Fragmentation of habitat and forests by humans undoubtedly has resulted in the increased range and densities of coyotes in North America, as coyotes readily take advantage of new habitat and prey opportunities. No habitat elements, other than prey base, have been found to be critical to coyotes. They use a variety of den sites: brush-covered slopes, steep banks, rock ledges, thickets, hollow logs, and dens of other animals (Bekoff 1982). Coyotes are active primarily from dusk to dawn (Bekoff 1982). During daylight, they avoid large open areas and traveled roads (Roy and Dorrance 1985).



Coyotes have a high reproductive potential, often reaching sexual maturity in one year and usually bearing a litter of five to six young per year. Coyotes are subject to various mortality factors, but in most situations, humans are the primary mortality agent. Annual mortality in adults is usually about 40 percent but can be as high as 70 percent in pups and yearlings (Gese et al. 1989, Voight and Berg 1987). Coyotes respond to high mortality rates with increased pregnancy rates and litter sizes (Voight and Berg 1987). Coyotes cannot compete well with wolves or mountain lions (*Felis concolor*) (which kill or force coyotes from their home ranges), but coexist with bobcats *(Lynx rufus)* (Major and Sherburne 1987, Voight and Berg 1987, U.S. Fish and Wildlife [USFWS] 1996, Witmer and deCalesta 1986). They are intolerant of foxes (*Vulpes* spp.), killing the foxes or forcing them out of occupied home ranges (Major and Sherburne 1987). They compete with all forest carnivores for carrion and other mammalian prey.

Coyote Issues in the Basin

Coyotes are common throughout the Western United States. Their numbers in most states are stable or increasing, despite intensive control efforts in livestock production areas (USDA 1994). Coyotes are habitat and diet generalists, filling niches vacated or made more available by lowered numbers and ranges of other forest carnivores. Currently, coyotes come into conflict with human interests more so than any other forest carnivore. Two issues are of concern to the conservation and management of coyotes in the basin.

Issue 1: Increased range and densities of coyotes—While most forest carnivore species have declined in range and numbers because of habitat alteration and other human activities, coyotes have responded positively to human activities. Because coyotes compete with other forest carnivores for carrion, small mammals, young ungulates, and fruits, increasing densities of coyotes can be considered detrimental to declining populations of other forest carnivores. If conditions for other larger, forest carnivores are improved, coyote range and densities should decline because they do not compete well with larger carnivores.

Key environmental correlates—The following information is available on basin GIS:

- Ungulate ranges
- Forest cover, structure, interspersion
- Road density
- Human density
- Large carnivore ranges (grizzly bear [*Ursus arctos*], mountain lion, wolf)

The following information is not currently available on basin GIS:

- Ungulate densities
- Small mammal ranges, densities
- Livestock grazing areas, densities
- Garbage dumps, landfills

Issue 2: Increased conflicts between coyotes and humans—As the range and densities of coyotes have increased, conflicts with humans have increased. Responding to a greater mix of habitats and more diverse and abundant food sources, coyotes have increased their tolerance and association with human habitations. This has resulted in increased predation on livestock and pets, consumption of garden and field crops, disease hazards, and attacks on humans. This pattern will probably continue as the human population and their activities expand into what once were remote areas.

Key environmental correlates—The following information is available on basin GIS:

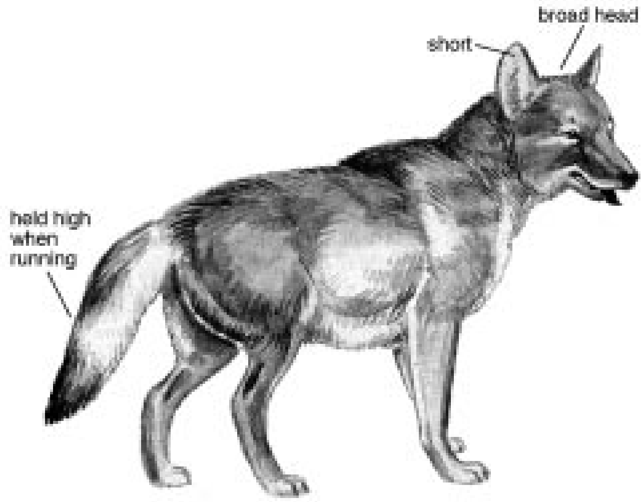
- Human density
- Road density
- Forest cover, structure, interspersion
- Agricultural areas

The following information is not currently available on basin GIS:

- Homesite density
- Garbage dumps, landfills
- Livestock grazing areas, densities

Gray Wolf (*Canis lupus*)

Ecology



The gray wolf originally was found throughout most of the Northern Hemisphere north of latitude 20^{o} N. (Mech 1974). In recent history, the gray wolf occupied most of the North American continent, with the primary exception of Baja California and the southeastern coastal plain of the United States (Paradiso and Nowak 1982). Thus, wolves once were one of the most widely distributed of all land mammals (Nowak 1983). In the United States, breeding wolf populations currently are found in Alaska, around Lake Superior, and in the northern Rocky Mountains (Van Ballenberghe 1992). In the interior Columbia basin, established packs of naturally occurring wolves are found only in western Montana. Experimental releases to establish new breeding populations have occurred recently in central Idaho and Yellowstone National Park (appendix A; USFWS 1996). It appears that these releases will be successful in establishing breeding wolf packs (USFWS 1996).

Even with the extensive distribution and use of diverse habitats and prey by wolves, their home range sizes differ considerably among regions. The limited comparisons that may be drawn from different studies support this expectation. Investigators have reported home ranges varying from 94 km^2 in Minnesota to about 13 km^2 for a wolf pack in Alaska (Mech 1970). The smaller home ranges (about 125 km^2) occur in forested habitats with high deer (*Odocoileus* spp.) populations, and the larger annual ranges (about 500 to 1400 km^2) are found for wolves preying on bison (*Bison bison*), moose (*Alces alces*), or caribou (*Rangifer* spp.) (Carbyn 1987). Summer home ranges are smaller because breeding and activities focused at den sites with pups; in winter, packs move across larger areas. Wolves can travel and disperse over very large distances (Carbyn 1987, Paradiso and Nowak 1982). Wolf densities differ widely because of variation in their prey base. Wolf densities have been estimated for areas from the size of Isle Royale, Michigan (546 km^2), to the Northwest Territories (1248000 km^2) (Paradiso and Nowak 1982). The highest densities of about one wolf per 26 km^2 occur in forested regions of Minnesota; much lower densities of about one wolf per 150 to 500 km^2 are found in the northern parts of their range in Alaska and Canada.

Gray wolves specialize in their prey but primarily eat ungulates and beaver *(Castor canadensis)* (Carbyn 1987). Prey smaller than beaver typically do not form large parts of the wolf diet, although snowshoe hares *(Lepus americanus)*, squirrels, and microtine rodents may be taken during some periods of the year when particularly abundant. Beaver are taken more heavily during summer, depending on their availability in a region. In general terms, ungulates comprise about 85 to 95 percent of the wolf diet and wolf populations cannot be sustained without populations of deer, moose, elk *(Cervus elaphus)*, bison, or caribou. Domestic livestock, including cattle and sheep, are taken as well. Wolves also feed on carrion.

As habitat generalists, wolves are not restricted to specific habitats. The only conspicuous unoccupied habitats are desert areas having few ungulate prey and tropical rain forests (Carbyn 1987).

Although denning sites may be limited in tundra areas, it seems highly unlikely that they would be so in forested or prairie regions throughout the rest of the wolf range. Dens often are within 500 m of water on elevated knolls in forested areas, but dens have been found in rock crevices, beaver lodges, hollow logs, and underneath tree stumps (Carbyn 1987). After several weeks, pups are moved to a succession of activity sites farther away from the den, known as rendezvous or home sites. Thus, it is unlikely that availability of suitable denning or rendezvous sites places any major restrictions on wolf distribution throughout most of the range.

Natural mortality factors include starvation, disease, intraspecific aggression, predation, and injuries received while attempting to kill large prey (i.e., moose). In most areas of North America, humans are the primary mortality factor for adult wolves. About 80 percent of the mortality of radio-marked wolves in north-central Minnesota was caused by humans (Fuller 1989). Human-caused mortality may be limiting population growth in Wisconsin and Michigan (Peek et al. 1991, Weise et al. 1975). There is no harvest season on wolves in any state within the Columbia basin.

Offsetting the susceptibility to human-caused mortality is a high capacity for reproduction and population growth. In the wild, females may reach sexual maturity at 22 months, although wolves often do not breed until their third year or later. Average litter size is about 6; range 1 to 11 (Mech 1974). Survival rates from birth to 5 to 10 months of age may range from 6 to 43 percent. Survival from this point to age 17 months may be about 55 percent, and annual survival after age 17 months may be about 80 percent (Mech 1970). Annual survival rates may differ substantially, depending on the relative importance of disease, starvation, and human-caused mortality.

Gray Wolf Issues in the Basin

Humans are the major predators and source of mortality for mature wolves, whether wolves are legally protected in an area or not. Consequently, the only major issues facing both natural and reintroduced wolf populations in the basin are whether humans will allow the wolves to survive by not killing them directly. Of secondary importance is the maintenance of adequate ungulate populations as a prey base. Other environmental factors such as denning or rendezvous sites are unlikely to be limiting to populations.

Studies in Ontario and the north-central United States demonstrate a strong inverse relation between road density and wolf populations (Paquet and Hackman 1995, Thiel 1985). Wolf populations are either absent or low when road densities exceed about 0.58 km/km^2. Hunting, trapping, poisoning, and predator control programs are the most common sources of human-caused mortality. Mortality associated with highways has now become a primary source of mortality in the Canadian Rocky Mountains, and increased road development and human settlement may be threatening the security of recently recovered populations in this area (Paquet 1993). Major highways also may be barriers to movements and dispersal of wolves, which further isolates subpopulations from each other. Three issues are of concern to wolf conservation and management in the basin.

Issue 1: Maintenance of large, remote areas with limited accessibility to humans—Wolves are able to survive in large areas of forested or open habitats, such as prairie and tundra, where there is limited human access. Increased human access into wolf habitats seems to limit population growth or occurrence because of legal and illegal killing and accidental mortality. Both the short- and long-term survival of gray wolf populations in the basin depend on maintaining large land areas with limited road access. Because wolves are persecuted more on private lands, large areas of public lands and designated wilderness are important to conserving wolf populations in the basin. Such areas will be the foci of restored or recovered wolf populations.

Key environmental correlates**—**The following information is available on basin GIS:

- Human density
- Road density
- Agricultural lands
  1. Grazing lands
  2. Croplands
- Wilderness and large roadless areas

The following information is not currently available on basin:

- Hunter use days

Issue 2: Shooting, trapping, poisoning, and predator control activities—Wolves come into conflict with humans primarily over livestock and perceived competition for game animals. Livestock producers and a large segment of the public in regions occupied by wolves have negative attitudes about wolves. Consequently, human-caused mortality is significant, even when wolves are legally protected, and affects the potential for wolf population growth and viability. Wolves also may be killed accidentally during coyote control activities.

Key environmental correlates—The following information is available on basin GIS:

- Agricultural lands
  1. Grazing lands
  2. Croplands

The following information is not currently available:

- Density of cattle, sheep, and other domestic livestock

Issue 3: Maintenance of adequate ungulate prey populations—Wolf populations depend on ungulates as their primary source of prey. Excluding associated human-caused mortality, wolves benefit from dense ungulate populations, which the wolves follow seasonally as ungulates move from summer to winter ranges. Wolves may limit ungulate populations, although their ability to regulate them is controversial. Protection and management of ungulate wintering ranges is important to provide concentrations of prey during times of the year when food is most limited. Abundance of carrion through natural processes (e.g., disease) also is an important food source for wolves.

Key environmental correlates—The following information is available on basin GIS:

- Ungulate ranges

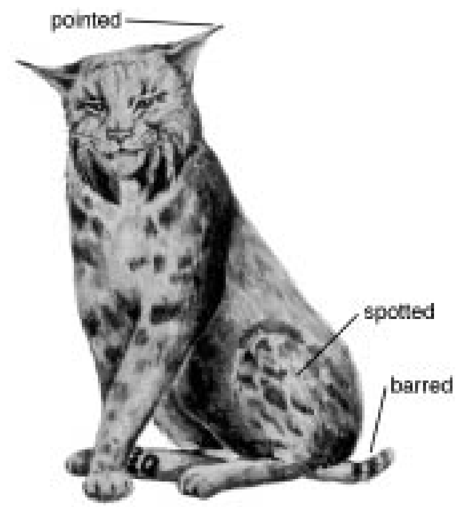
The following information is not currently available:

- Prey availability
  1. Average annual ungulate density
  2. Ungulate density on their wintering range
- Ungulate harvest

Bobcat (*Lynx rufus*)

Ecology

The bobcat is the most widely occurring felid in North America (Anderson 1987). The species occurs throughout the interior Columbia basin (appendix A). It is widely distributed across the Lower 48 States and Mexico, but its ecological niche throughout Canada and Alaska is occupied



by the lynx (*Lynx canadensis*), which is better adapted to the deep snows of boreal forest winters (McCord and Cardoza 1982). The range of the bobcat has expanded owing to some human activities; however, recent intensive forestry and agriculture (Midwestern States) or dense human settlement (Middle Altantic States) has eliminated or restricted the range of bobcats in some regions (Rolley 1987).

Bobcats are territorial and, for the most part, live solitary lives (Anderson 1987, McCord and Cardoza 1982). The home ranges of females typically do not overlap much, but male home ranges may overlap with females or other males. There also are transients—individuals without an established home range that may move as much as 6+ km every few days (McCord and Cardoza

1982). Females are only about half the size of males and typically have home ranges two to three times smaller. Home range sizes are highly variable, usually 1 to 100 km^2, but can be as large as 200 km^2 and are usually larger in more northerly areas (Anderson 1987, McCord and Cardoza 1982).

Bobcats are opportunistic predators, feeding on a wide array of prey: mice, voles, rats, lagomorphs, beaver, squirrels, deer, birds, insects, fish, and reptiles may be consumed (McCord and Cardoza 1982, Toweill 1982). Lagomorphs are probably the main prey item over most of the range of the bobcat, but there may be distinct regional differences: deer are commonly fed on in winter in the Northeastern States (Anderson 1987, Rolley 1987) and the mountain beaver (*Aplodontia rufa*), a burrowing rodent, is heavily used in the Oregon Coast Range (Witmer and deCalesta 1986). Although bobcats may feed on deer as carrion, their ability to kill adult deer is well documented (McCord and Cardoza 1982). In some cases, bobcats have had a substantial impact on game populations because of the amount of predation on deer fawns or pronghorn antelope (*Antilocapra americana*) calves (McCord and Cardoza 1982). Some livestock depredation occurs—especially with lambs, goats, and poultry—but the problems usually are localized and relatively minor (Anderson 1987, Rolley 1987).

Bobcats are adapted to a wide variety of habitats, but use “broken and rugged country” to a large extent (McCord and Cardoza 1982). A mixture of forested area with openings provides cover and an adequate prey base (Rolley 1987). Rock piles and rocky ledges and outcrops provide important natal dens and shelters, although brush piles and hollow logs or trees also are used (McCord and Cardoza 1982, Rolley 1987). Deep snow (15 cm) restricts the movements of bobcats (Anderson 1987). Unlike many of the larger forest carnivore species, bobcats are fairly compatible with moderate levels of human activities and development (McCord and Cardoza 1982).

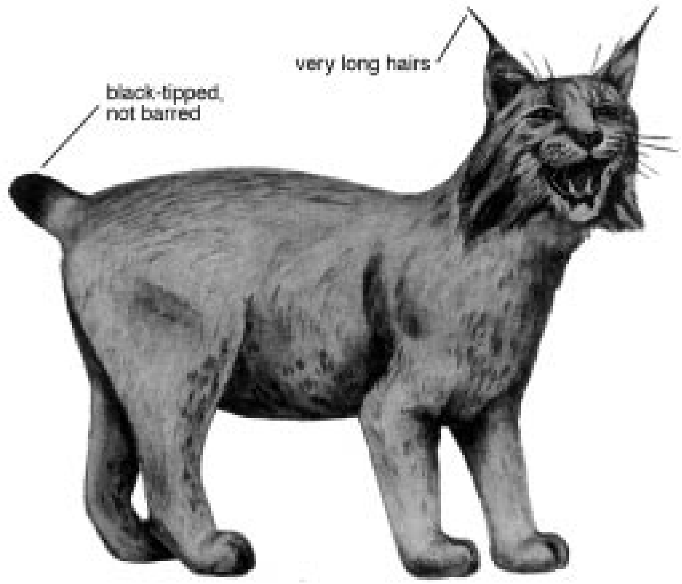
Relatively few bobcats live to 9 or 10 years of age in the wild (McCord and Cardoza 1982). They have moderate reproductive potential; females are sexually mature at 1 or 2 years of age and usually have one litter per year of two to three young (McCord and Cardoza 1982, Rolley 1987). Mortality rates can be relatively high for kittens and juveniles, especially if prey is not abundant (Anderson 1987, McCord and Cardoza 1982). Various mammalian and avian predators can take young bobcats, and adults can be killed by mountain lions and coyotes. Cannabalism occurs with bobcats (Anderson 1987, Zezulak and Minta 1987). Quills from porcupines (*Erethizon dorsatum*) also kill some bobcats (Anderson 1987). Mortality rates in adult bobcats are relatively low (about 3 percent per year), and harvest by humans accounts for most of that (McCord and Cardoza 1982, Rolley 1987). Populations can be overharvested, and because of the inclusion of bobcats in a CITES (Convention on International Trade in Endangered Species) appendix, populations and harvests are closely monitored by state wildlife agencies (Anderson 1987, Gluesing et al. 1986, Rolley 1987). Abundant coyote populations may limit the range and distribution of bobcats (Anderson 1987), although the two species can coexist where there is good habitat and an abundant prey base (Witmer and deCalesta 1986).

Bobcat Issues in the Basin

Bobcats are widespread in forested and rangeland areas of the Western United States. A mixture of habitats and an adequate and diverse prey base provides for their needs. Bobcats are compatible with most human land uses. State wildlife agencies must continue to monitor bobcat populations and harvests to avoid overharvest and to comply with CITES requirements. Because the habitat needs of bobcats are easily met and because there are no serious conflicts between humans and bobcats, no specific issues of concern to conservation and management of bobcats in the basin were identified.

Lynx (*Lynx canadensis*)

Ecology



The lynx is holarctic in distribution and ranges across Alaska and Canada (McCord and Cardoza 1982, Quinn and Parker 1987). It is absent in unforested areas in the far north. In the Lower 48 States, lynx are found in limited areas of north-central and northeastern Washington, western Montana and Wyoming, and northern Colorado (appendix A). In the Midwestern and Eastern United States, lynx occur at the northern edge of the country, contiguous with lynx range in Canada that skips the southern prairies but follows forested regions to the east. Lynx distribution has not changed dramatically since historical times but has receded from historical southern limits, where its occupancy may have been somewhat tenuous (Quinn and Parker 1987).

Home range sizes for lynx are reported as about 16 to 20 km^2, with those of males being somewhat larger than those of females (Quinn and Parker 1987). Home ranges often overlap, but lynx avoid interaction through temporal separation (Brand et al. 1976, Keith 1974, Nellis et al. 1972). Factors that contribute to the size and shape of lynx home ranges include prey and lynx densities and physiography (Koehler and Aubry 1994). Lynx often travel 5 to 10 km per day and may disperse over 100+ km (McCord and Cardoza 1982).

Lynx are highly dependent on snowshoe hares as prey but also take voles, mice, squirrels, and grouse (Quinn and Parker 1987). Snowshoe hares are particularly important during winter; greater diversity of diet is available in summer (Koehler and Aubry 1994). Despite this greater diversity, snowshoe hares still make up the majority of diet biomass (Brand et al. 1976). Lynx can thrive on a diet of only snowshoe hares but will switch to other prey when hare density declines. Lynx occasionally will take ungulate prey, especially young caribou or moose (Saunders 1963). In Washington, Koehler (1990) found that tree squirrels represented 24 percent of food items in lynx diet.

Lynx are found in boreal forest habitats throughout their range (Quinn and Parker 1987). In the southern portions of their range, lynx are associated with boreal forest typically found in higher elevations of montane regions (McCord and Cardoza 1982). Lynx habitat in the mountains of the Western United States consists of early successional forest, used as foraging habitat because of its value to the snowshoe hare, and late successional forest, containing optimal sites for denning (Koehler and Aubry 1994). Lynx use hollow logs, stumps, deadfalls, and caves for dens (McCord and Cordoza 1982). Lynx require a mosaic of seral stages of forest connected by stands suitable for travel cover; foraging habitat must be near den sites. This habitat is described as intermediate seral stage forest.

Like bobcats, lynx have a moderate reproductive potential: females are sexually mature at 1 or 2 years of age and usually have one litter per year of three to four young (McCord and Cardoza 1982, Quinn and Parker 1987). The bobcat has expanded its range north since historical times, and evidence suggests lynx densities will decrease where bobcats increase (Quinn and Parker 1987). Several other major competitors for snowshoe hares exist in the southern limits of lynx range and include coyotes, foxes, and raptors; all contribute to the lowered availability of hares to lynx. Roloff[2] contends that natural balance of these predators and prey populations would be of no concern, but that many of the competing predators respond positively to human-induced habitat alteration, and community relations thus are influenced by human activities to the detriment of the lynx. Lynx may benefit, however, from alteration of forest habitat to early seral stages, which provides optimal habitat to snowshoe hare. Koehler and Aubry (1994) also state that in undisturbed environments, the lynx may have an advantage over many potential competitors because it is well adapted to deep snows at high elevations, but roads and snowmobile trails increase access for lower elevation predators to these formerly remote lynx areas, and thus increase the potential for competiton. Direct predation on lynx is rare, but wolves have been documented as predators on lynx in Scandinavia and Russia (McCord and Cardoza 1982).

Lynx Issues in the Basin

The largest populations of lynx in the conterminous United States occur in northern Washington and Montana (Koehler and Aubry 1994). These populations are isolated naturally by the montane distribution of boreal forests at these latitudes, and by the distribution of the primary prey of the lynx, the snowshoe hare, which is found at lower densities than further to the north. A number of other predators compete with lynx at the southern limits of its range for snowshoe hares, and some of these predators respond positively to human-induced habitat alteration. Increased competition for prey will have a negative impact on lynx. All these factors increase the vulnerability of lynx populations. Two issues are of concern for lynx conservation and management in the basin.

[2] Roloff, G. 1995. Canadian lynx *(Felis lynx)* in Idaho: habitat conservation assessment and conservation strategy. 13 p. Unpublished report. On file with: Idaho Department of Fish and Game, 600 S. Walnut, P.O. Box 25, Boise, ID 83707.

Issue 1: Conservation of appropriate mosaics of seral stages in boreal forest habitat—Lynx require early seral stage boreal forest habitats, but stands may not support many snowshoe hares for 10+ years after clearcutting and may not become optimal hare habitat for an additional 20 years postharvest (Koehler and Aubry 1994). Snowshoe hares prefer densely stocked stands of small-diameter trees. Preferred stands, with highest hare densities, had reported tree densities of 6,000 to 22,000 stems/ha throughout the range of the snowshoe hare (Koehler and Aubry 1994).

Only relatively small patches of late-successional forest are needed to provide denning opportunities for lynx, but these must be connected by adequate travel habitat to foraging habitat. Frequent, small patches of habitat alteration that mimic natural patterns of disturbance are proposed by Koehler and Aubry (1994) as a model for lynx habitat management. Landscape-level planning of the optimum mix of stand ages is necessary for lynx conservation, and planning for delay in development of quality, even as foraging habitat, will be required. Catastrophic wildfire would eliminate the mix of seral stages that create optimal lynx habitat, and fire management plans should recognize this hazard.

The ranges of lynx, bobcats, and coyotes may overlap, and competition for snowshoe hares may be of significant concern (Koehler and Aubry 1994). Alternate prey might alleviate competitive pressure.

***Key environmental correlates*—**The following information is available on basin GIS:

- Boreal forest type
  1. 10 percent of area (drainage) in late-successional forest
  2. 30 to 50 percent of area in early successional forest (10 to 30 years old, ≥ 6,000 stems/ha)
  3. Remainder of area in intermediate age classes, with continuity between these 3 types; that is, no lengthy, wide stands <10 years old that could serve as barriers to movement
- Fire hazard rating

The following information is not currently available on basin GIS:

- Log piles, blowdowns
- Deer fawning areas
- Tree squirrel density

Issue 2: Harvest and human disturbance— Lynx are protected in most states of the interior Columbia basin, but they are classified as furbearers in Idaho and Montana (Koehler and Aubry 1994). Trapping mortality may be critical in reducing lynx populations below threshold limits, particularly when populations may be low naturally because of declining or naturally low prey populations (Brand and Keith 1979, McCord and Cardoza 1982). Where lynx are legally protected, an increase in roads through lynx habitat increases human access and human-lynx encounters, as lynx also use roads for hunting and travel (Koehler and Aubry 1994). Increased road density therefore leads to increases in poaching, road kill, and incidental mortality of lynx. Additionally, increased snowmobile use in key lynx habitat may allow access by other, competing predators.

Key environmental correlates—The following information is available on basin GIS.

- Road density
  1. $\leq$1.6 km/2.6 km^2
  2. Highway location and density

The following information is not currently available on basin GIS:

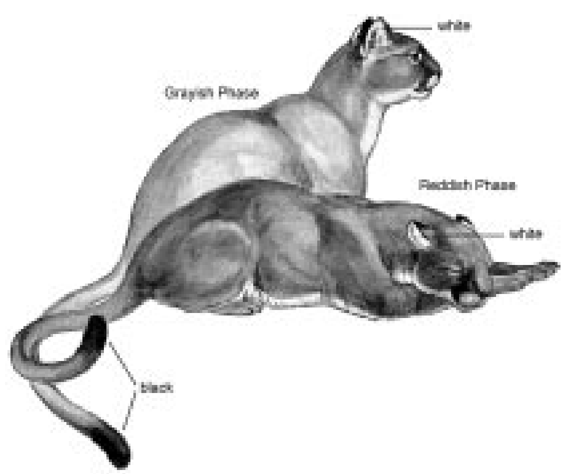
- Off-road motorized recreational vehicle use areas

Mountain Lion (*Felis concolor*)

Ecology

At one time the range of the mountain lion was perhaps the most extensive of any terrestrial mammal in the Western Hemisphere, extending from the southern Yukon of Canada to the tip of Chile (Dixon 1982, Lindzey 1987). Its range has declined dramatically in the Eastern and Midwestern United States; however, it is still relatively widespread in the Western States, including the interior Columbia basin (appendix A; Dixon 1982, Lindzey 1987). The range of this large, solitary, mobile predator originally corresponded closely to that of major prey species—in particular, with the ranges of ungulates such as mule deer (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*)—irrespective of habitat or cover type. There has been a reduction in portions of its range because of conflicts with livestock and native ungulate management. More recently, the removal of bounties, restrictions on mountain lion harvests, and increasing deer populations have resulted in increases in the distribution and densities of mountain lions (Dixon 1982, Lindzey 1987).

Mountain lions are territorial with large home ranges because of their size and food requirements. Home ranges sizes can be from 120 to



1000 km^2 for males and 32 to 1000 km^2 for females (Dixon 1982, Lindzey 1987, Seidensticker et al. 1973). Home ranges may overlap between males and females and between residents and transients, although resident males seldom overlap (Lindzey 1987, Seidensticker et al. 1973). The size of the home range also is related to the seasonal pattern and density of prey; seasonal ranges often are much smaller than the annual range (Dixon 1982, Seidensticker et al. 1973). Mountain lions (except females with kittens) are very mobile and can move 10+ km in a day; young animals may disperse as far as 50+ km (Lindzey 1987).

Mountain lions are almost exclusively carnivorous, feeding mainly on ungulates (deer, elk, moose) but also on a variety of smaller mammals, such as porcupines, jackrabbits (*Lepus* spp.), snowshoe hares, beaver, ground squirrels (*Spermophilus* spp.), marmots (*Marmota* spp.), and other small rodents (Dixon 1982, Lindzey 1987). An adult mountain lion will kill, on average, one ungulate every 7 to 10 days; very young and very old ungulates are most vulnerable (Dixon 1982, Lindzey 1987). It is not clear whether mountain lions can regulate ungulate population densities, although some researchers speculate that they do (Anderson 1983). Where available, some mountain lions will prey on cattle (mainly calves) and sheep (all ages; Dixon 1982, Lindzey 1987). Losses from lions are rarely significant among all losses across the domestic livestock industry, although losses for individual operators may be substantial. Dispersing young males and older, injured adult lions seem to account for most of the depredations. Mountain lions have strong predatory instincts, and surplus killing and caching of carcasses is reported (Dixon 1982, Holt 1994). They also feed on carrion when and where available (Anderson 1983).

Although mountain lions occupy a wide variety of habitats and elevations, they seem to prefer open or mixed forest and shrubby cover types (Dixon 1982, Lindzey 1987). Within these types, steep rugged areas with rocky cliffs or ledges are preferred. Females use a variety of sites in which to give birth (caves, shallow nooks in rock cliffs, boulder piles, brush thickets, uprooted trees, or fallen logs) and require only cover to keep out heavy rain and hot sunlight (Dixon 1982, Lindzey 1987). Most adult mountain lions avoid roaded areas, recently logged areas, and areas of human activity (VanDyke et al. 1986a, 1986b). Increased sightings and conflicts with lions in urban and suburban settings may be due to dispersing juveniles from expanding lion populations.

Mountain lions are long-lived (12+ years) and have a moderate reproductive potential. Females are sexually mature by 2.5 years and may bear a litter of two to three kittens every year, although birthing occurs every other year in some areas (Dixon 1982, Lindzey 1987, Lindzey et al. 1994). Mountain lions can die from several causes (injuries sustained while capturing prey, starvation, accidents, disease, intraspecific fighting), but human-caused mortality is usually the largest source (Anderson 1983, Dixon 1982, Lindzey 1987). As with many mammalian species, the very young and the very old have the lowest survival rates. Resident adult lions had an average 74 percent annual survival rate (range 52 to 100 percent) in a study conducted in southern Utah (Lindzey et al. 1988). Mountain lions in areas of good habitat can respond relatively quickly with density increases when hunting pressures are removed (Ross and Jalkotzy 1992). Mountain lions compete with other forest carnivores for prey, but they are probably rarely killed or injured by other carnivores. Wolves are known to kill mountain lions (Boyd and Graham 1992, Paquet and Hackman 1995). Mountain lions will kill smaller carnivores such as bobcats, coyotes, and foxes (Boyd and O’Gara 1985, Lindzey 1987).

Mountain Lion Issues in the Basin

Mountain lions are widespread in forested, mountainous areas of the Western United States. To maintain viable populations, lions require areas of abundant prey and cover and relatively little human activity. Overharvest by humans is a concern in some areas; however, where lion harvests have ceased or been severely restricted and ungulate prey densities have grown, increased lion densities have rapidly occurred with an increase in conflicts with humans. Two issues are of concern to conservation and management of mountain lions in the basin.

Issue 1: Provision of appropriate habitat and adequate prey—Mountain lions can thrive in many habitats and on several prey species. Where humans are present and alter habitats or prey abundance, or overharvest lions, lion population density may decrease and become vulnerable to local extirpation. Regulation of lion harvest, maintenance of tree and shrub cover, and provision of an abundant and diverse prey base will provide the needs of mountain lions, especially in rugged, remote forested areas. It is important to not overharvest, or otherwise substantially reduce, important prey populations (especially ungulates). Adequate corridors for dispersal and interaction of subpopulations must be provided to maintain population viability (Beier 1993, 1995). Highways can reduce the effectiveness of forested corridors as dispersal routes (Paquet and Hackman 1995). Mountain lion requirements for dispersal corridors have not been well studied or defined; however, they appear to be easier to meet than those for other large, far-ranging forest carnivores, such as grizzly bears and wolves.

***Key environmental correlates*—**The following information is available on basin GIS:

- Forest cover, structure, interspersion
- Ungulate ranges
- Physiography (slope, elevation)
- Forested corridors
- Highways

The following information is not currently available on basin GIS:

- Ungulate densities, harvests
- Mountain lion harvest units, limits

Issue 2: Reduction of conflicts with humans—Many sociopolitical pressures affect the management of mountain lion populations (Mansfield 1994). Many people want to have mountain lion populations nearby, and urban-suburban and recreational expansion into mountain lion habitats is increasing with resultant increases in attacks on humans and livestock (Paquet and Hackman 1995). Precautions, such as not letting a lone individual hike ahead of the group and responding aggressively to a lion encounter, must be taken to reduce the increasing number of attacks on humans (Beier 1991, Hanson 1995).

***Key environmental correlates*—**The following information is available on basin GIS:

- Human density
- Road density
- Agricultural lands

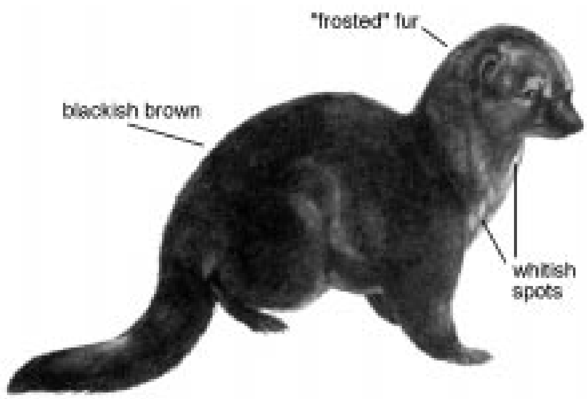
The following information is not currently available on basin GIS:

- Livestock grazing areas, densities
- Campgrounds, recreational developments
- Trail locations, densities

Fisher (*Martes pennanti*)

Ecology

Fishers occur only in North America. The southern extent of their range from Illinois to Virginia was severely restricted by the early 1900s by habitat loss induced through logging, fire, and settlement (Douglas and Strickland 1987). Trapping further reduced fisher populations on their shrinking range. In the interior Columbia basin, fishers occur primarily in the Cascade Range and Rocky Mountains (appendix A).



Home range sizes in Idaho average 83 km^2 for male fishers and 41 km^2 for females (Jones 1991) and probably reflect true space requirements for the species in the northern Rocky Mountains (Heinemeyer 1993). In California, Buck et al. (1979) found male fishers have home ranges of 18 km^2, and female home ranges average 3.6 km^2. These studies represent the extent of available research to date into fisher home ranges in the Western United States. Home ranges of fishers frequently overlap, although there may be temporal separation of adults of the same sex (Coulter 1966, de Vos 1951, Kelly 1977, Powell 1977). Fishers probably can disperse 40+ km.

Fisher diet is varied throughout the range of the species (Martin 1994). The most important fisher foods reported in the literature include snowshoe hares, porcupines, deer, passerine birds, and a variety of vegetation. Redback voles (*Clethrionomys* spp.), red squirrels *(Tamiasciurus hudsonicus)*, and shorttail shrews *(Blarina brevicauda)* also have been reported in fisher diets. Seasonal changes in fisher diets have not been documented with clarity, although it is likely that this opportunistic predator exhibits seasonality in diet (Martin 1994). In Idaho, mammalian prey had the highest frequency of occurrence in the diet of fishers, and included snowshoe hares, red squirrels, redback voles, and beaver (Jones 1991). Similarly, diets of fishers in Montana were dominated by snowshoe hares and carrion, with a variety of small mammals also representing large portions of the diet (Aune and Schladweiler 1993, Roy 1991). Carrion may be a seasonally important food item, particularly during winter.[3] Additionally, prey switching was observed in Idaho by Jones (1991), where fishers frequently took red squirrels more often in winter, when voles probably were less available.

Fishers usually are found in mixed forests with a diversity of tree species and ages. The diverse diet of the fisher probably requires a mix of forest habitat types for optimal habitat (Arthur et al. 1989). Johnson (1984) reported that fishers in Wisconsin often used areas of interspersion, most likely because prey were more diverse at habitat edges.

Fishers select habitats with relatively high canopy cover (Powell 1982). Fishers preferred closed, multilayered fir stands in northwestern California, and avoided hardwood stands (Buck et al. 1979). Fishers have used diverse forest habitats in Washington, but these also have relatively high canopy cover (Aubry and Houston 1992). In Idaho and Montana, mesic forest habitats at low or mid elevations are important fisher habitat (Jones 1991, Heinemeyer 1993). Deep snow accumulation, as typically occurs at high elevations, appears to limit fisher movements and distribution (Arthur et al. 1989, Aubry and Houston 1992, Heinemeyer 1993). Riparian corridors are especially important habitat, serving as travel corridors and providing rich habitat for fisher prey (Buck et al. 1979, Jones 1991, Heinemeyer 1993).

[3] Heinemeyer, K.; Jones, J. 1994. Fisher biology and management in the Western United States: a literature review and adaptive management strategy. 109 p. Unpublished report. On file with: Department of Agriculture, Forest Service, Northern Region. Federal Building, P.O. Box 7669, Missoula, MT 59807.

Fishers have a moderate reproductive potential; they are sexually mature at 1 or 2 years of age, usually have one litter per year of three young, and remain sexually active to 8+ years of age (Douglas and Strickland 1987, Strickland et al. 1982b). Fishers may compete for food with coyotes, foxes, bobcats, lynx, martens, wolverines *(Gulo gulo)*, and weasels *(Mustela* spp.*)* (Powell and Zielinski 1994). Martens and fishers are the most likely direct competitors, as both are capable of hunting arboreally. Sympatry has been documented in Idaho and California (Powell and Zielinski 1994). Fishers may have a competitive advantage because of their larger size, although the smaller marten can specialize on voles (Martin 1994), and it is difficult to accurately predict the impact of sympatry and competition on populations. Management objectives for both species for a single land unit may conflict, however.

Fisher Issues in the Basin

The status of the fisher in the Western United States is poorly known but generally perceived as precarious and declining (Powell and Zielinski 1994). This is a serious issue alone, but it also is a component of the larger problem of the decline of biological diversity (Wilson 1988). Recovery of species of concern must necessarily focus on the population level, because this is the scale at which genetic variation occurs and because population are the constituent elements of communities and ecosystems.[4] Systematic habitat alteration and overexploitation have reduced the historical distribution of fishers in suitable habitat in the interior Columbia basin to isolated and fragmented populations. Current populations may be extremely vulnerable to local and regional extirpation because of their lack of connectivity and their small numbers. Four issues are of concern to fisher conservation and management in the basin.

[4] Weaver, J. 1993. Lynx, wolverine, and fisher in the Western United States. 132 p. Unpublished report. On file with: U.S. Department of Agriculture, Forest Service, Northern Region, Federal Building, P.O. Box 7669 Missoula, MT 59807.

Issue 1: Conservation of late successional forest at low to mid elevations—The range and population levels of the fisher have declined substantially in the past century, primarily the result of trapping pressure and habitat alteration through logging (Powell and Zielinski 1994). Additionally, large-diameter logs and snags are critical habitat features for fishers, providing maternal and natal dens, and these features are particularly vulnerable to decline in availability in harvested forest landscapes. Finally, conservation of fishers will require areas of suitable habitat large enough to hold a minimum number of contiguous fisher home ranges. Past decades of timber harvest in many areas of the basin have fragmented forest habitat, thereby reducing the contiguous area and creating barriers to movement.

Fishers probably can tolerate small patch cuts or other small-scale disturbances, provided these occur in a larger matrix of relatively dense, closed canopy, late successional forest (Powell and Zielinski 1994). Such openings might even increase the value of habitat by providing a diversity of prey, which will support a diverse diet for fishers.

***Key environmental correlates*—**The following information is available on basin GIS:

- Coniferous forest
  1. ≥20 percent of unit mature forest
  2. ≥40 percent additional heterogenous aged forest

The following information is not currently available on basin GIS:

- Coarse woody debris
  1. Medium to high fuel loadings
  2. Large logs

Issue 2: Maintenance of links between populations—Fishers can travel relatively long distances, and daily movement of 5 to 6 km has been documented repeatedly (Johnson 1984, Jones 1991, Kelly 1977, Roy 1991). Barriers to movement may include large nonforested openings and highways. Maintenance of links between individuals and populations will require elimination or reduction of these barriers.

***Key environmental correlates*—**The following information is available on basin GIS:

- Nonforested habitat
- Highway location and density

Issue 3: Maintenance of riparian corridors for use by individuals and populations—Riparian corridors are documented as important habitat for fishers in several studies. They provide travel routes and often are found at the lower elevations fishers prefer within a given area. The high canopy cover and structural complexity of riparian habitat support relatively abundant and diverse populations of small mammals and birds, and these sites may be important prey patches for fishers.

***Key environmental correlates*—**The following information is available on basin GIS:

- Riparian corridors (≥3d order streams available only)

The following information is not currently available on basin GIS:

- Riparian corridors, 1st and 2d order streams

Issue 4: Trapping pressure and human disturbance—Fishers are formally protected in Washington and Oregon, and the trapping season has been closed in Idaho, although fishers do not have special status in that State (Powell and Zielinski 1994). Montana has had a trapping season for fishers with a quota of 20 animals.

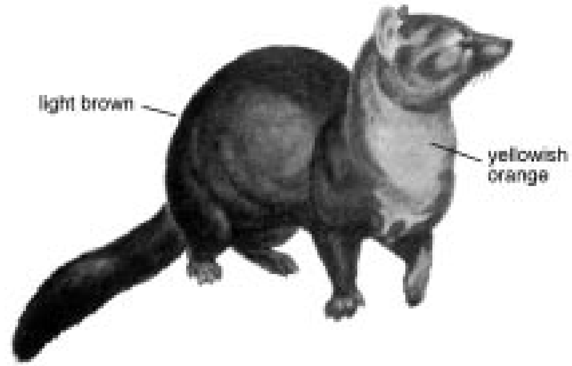
Fishers have relatively low fecundity, with females typically giving birth to only two young per year. Population sustenance and growth depend, then, on long-term adult survivorship (see footnote 4). This survivorship rate is imperiled in commercially exploited populations.

***Key environmental correlates*—**The following information is available on basin GIS:

- Road density ≤1.6 km/2.6 km^2

The following information is not currently available on basin GIS:

- Allowable fisher harvest by area
- Recent harvest data by area



American Marten (*Martes americana*)

Ecology

The American marten occurs only in North America but is closely related to three Eurasian species of *Martes*. Its geographic distribution ranges to the limit of trees in the Canadian and Alaskan north and as far south as northern New Mexico. In the Western United States, marten distribution is closely associated with late-successional mesic coniferous forest. The distribution of martens in Washington and Oregon has been reduced in recent decades, apparently the result of habitat alteration by logging (Buskirk and Ruggiero 1994). Martens occur in portions of the Cascade Range and Rocky Mountains within the interior Columbia basin (appendix A).

Numerous studies using both mark-recapture techniques and radio telemetry have found similar sizes for marten home ranges: male home range sizes reported in studies conducted in the Western United States are from 0.8 to 4.9 km^2 (Burnett 1981, Hawley and Newby 1957, Martin 1987, Spencer 1981). In these same studies, home range sizes for females are roughly half the size of male home ranges and range from 0.7 to 3.4 km^2. Home ranges frequently overlap both between and among sexes. Martens may disperse 40 to 60+ km (Strickland and Douglas 1987).

Voles are the most important food item in the diet of American marten throughout their range (Martin 1994). Diets vary tremendously and often include shrews, deer mice *(Peromyscus maniculatus)*, red squirrels, heather voles *(Phenacomys intermedius)*, northern flying squirrels *(Glaucomus sabrinus)*, northern pocket gophers *(Thomomys talpoides)*, fish, ungulates (as carrion), and Douglas squirrels *(Tamiasciuris douglasii)*. Diet is influenced by seasonal availability of some food items. Insects and fruit are eaten when available.

Marten prefer mature, mesic coniferous forests, with high structural diversity in the understory layers (Buskirk and Powell 1994, Buskirk and Ruggiero 1994). Structural diversity is contributed by coarse woody debris, the lower branches of living trees, and shrubs. These features provide resting sites for martens, subnivean access to prey habitat in winter, and predator avoidance cover (Buskirk and Ruggiero 1994). Forests lacking structural diversity, especially at ground level, are used little or not at all by martens. Preference for late-successional mesic forests is even more pronounced in winter, although martens are not migratory and home ranges do not shift (Campbell 1979, Soutiere 1979, Steventon and Major 1982). Dependence on access to subnivean prey provided by the complex structure of these forests, and the need for thermally superior coarse woody debris as resting sites in cold temperatures, may limit habitat use by martens to these forest types in winter (Buskirk and Powell 1994).

Martens have a moderate reproductive potential; like fishers, they are sexually mature at 1 or 2 years of age, usually have one litter of three young per year, and can be sexually active to 12+ years of age (Strickland et al. 1982a). Martens are vulnerable to predation because of their relatively small size, and predator avoidance cover has been noted as important to optimal marten habitat by many researchers. Raptors and owls are considered potential predators on martens (Buskirk and Ruggiero 1994). Fishers also have been documented as predators on martens (deVos 1952, Raine 1981). Fishers are likely to be important competitors with martens for prey, where the two mustelids are sympatric, as both feed on a variety of voles and other small mammals. Both mustelids are capable of arboreal hunting, as well, and may compete for squirrels. Sympatry of these two mustelids is documented in Idaho and California (Powell and Zielinski 1994).

Marten Issues in the Basin

Marten populations are among the least compromised of all mustelids in the interior Columbia basin, though the current range of the species is reduced from historical limits throughout the United States (Buskirk and Ruggiero 1994). The range of the marten has been especially fragmented in the Cascade Range as a result of habitat alteration by forest harvest. Marten range in the Rocky Mountains seems to be similar to historical distribution. Three issues are of concern to marten conservation and management in the basin.

Issue 1: Conservation of late successional forest—Research throughout the range of the marten has demonstrated the negative effects of timber harvest activities involving the substantial modification or removal of overhead canopy across large areas (Strickland and Douglas 1987, Strickland et al. 1982a). Thompson and Harestad (1994) reviewed 10 studies of marten habitat selection and found that martens consistently use early seral stage forests (shrub, sapling, and pole stage areas) relatively less than their availablility might indicate. They found that in all studies, only overmature stands are consistently preferred. Timber harvest reduced the value of forest habitat to martens through removal of overhead cover, removal of large-diameter coarse woody debris, and the conversion of mesic sites to xeric conditions (Buskirk and Ruggiero 1994). Additionally, catastrophic loss of late successional forest from wildfire is a concern because of the negative impact it would have on the conservation of martens and other wildlife associated with these habitats.

Little evidence yet exists to document the effects of forest fragmentation on martens. Relatively small home range sizes and tolerance of home range overlap suggest that martens may be capable of persisting in fragmented landscapes with blocks of forest large enough to accommodate multiple home ranges. Martens will not, however, travel far from substantial overhead forest cover, and thus direct links among remaining suitable habitat blocks are essential. Little is known about the effects on martens of increased edge and the reduction of forest interior that occurs with fragmentation. If these factors are detrimental to martens, it would further strengthen the need for conservative management of the forest landscape harboring marten populations. Large blocks of contiguous late successional forest provide suitable habitat, and it is unknown at what point fragmentation eventually creates unsuitable habitat (Buskirk and Ruggiero 1994).

Large-diameter snags, logs, and stumps provide important resting sites for marten (Martin and Barrett 1991). These authors recommend that snags and logs ≥80 cm be preserved for martens in any timber harvest. Coarse woody debris also provides habitat for prey species. Timber harvest typically reduces the density of large-diameter woody debris and the potential population from which these features are recruited.

***Key environmental correlates*—**The following information is available on basin GIS:

- Contiguous late successional coniferous forest
  1. ≥60 percent of unit
  2. Relatively low fragmentation
- High average canopy closure (≥60 percent)
- Fire hazard rating

The following information is not currently available on basin GIS:

- Coarse woody debris
  1. Large (≥81 cm diameter, 10 m length), intact, moderately decayed logs
  2. Large (≥81 cm diameter, 4.3 m tall), intact, moderately decayed snags
  3. Slash piles
  4. Squirrel middens
- Understory (woody stem density)

Issue 2: Maintenance of links between populations—Martens will not use habitat with minimal canopy cover. Forested travel corridors are essential for maintaining links among individuals and populations. Paved roads may not be significant barriers to movement, but mortality caused by vehicles on highways is documented (Martin 1987, Spencer 1981). This mortality factor may be incidental, but if populations decline and viability is at risk, any source of mortality will be a concern.

***Key environmental correlates*—**The following information is available on basin GIS:

- Nonforested habitat
- Road type, location and density

Issue 3: Trapping pressure and human disturbance—Martens are trapped commercially in most states of the basin (appendix C). The species is considered sensitive by the State of Oregon, and receives specific attention during management planning and implementation by the USDA Forest Service at most National Forests in the basin. These plans and regulations differ with Forest Service Region, but all identify the need to maintain late successional forest habitat to support viable marten populations. The need to coordinate habitat management with population management, to ensure population viability, will require interagency cooperation.

***Key environmental correlates*—**The following information is available on basin GIS:

- Road density—all roads, ≤1.6 km/2.6 km^2

The following information is not currently available on basin GIS:

- Allowable marten harvest by area
- Recent harvest data by area

River Otter (*Lutra canadensis*)

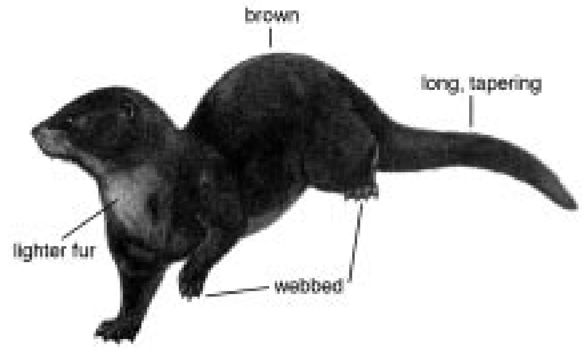
Ecology

River otters range from Florida to Alaska, but have been extirpated from more than one-third of their historical range, which included most of the North American continent (Melquist and Dronkert 1987). Extirpation has occured most dramatically in the central portion of the continent, and in the Southwestern United States. In the interior Columbia basin, river otters occur widely, but at low densities, in various river systems (appendix A).

River otters depend on aquatic and semiaquatic habitats, and their home ranges reflect this dependence in shape and size. Home range sizes ranged from 8 to 78 km^2 in Idaho (Melquist and Hornocker 1983) and were reported as 20 to 57 km^2 in Colorado (Mack 1985). Overlap of home ranges among and between sexes was extensive in the Idaho study. River otters may travel 10+ km per night (Toweill and Tabor 1982).

Fish are the most important prey of river otters (Melquist and Dronkert 1987, Melquist and Hornocker 1983, Toweill and Tabor 1982). Additionally, otters consume crustaceans, reptiles, amphibians, birds, insects, and mammals. Competition with other mammals for food has not been documented (Melquist and Dronkert 1987, Melquist et al. 1981). In Idaho, negative impacts of river otters on prey populations of fish were not found (Melquist and Hornocker 1983).

Aquatic habitats associated with areas ranging from coastal intertidal zones to freshwater streams and lakes provide river otters with suitable habitat (Melquist and Dronkert 1987, Toweill and Tabor 1982). River otter density seems to be related conversely with pollution levels and associated human density (Toweill and Tabor 1982). In the northern regions of their continental range, otters are limited by the availability of winter habitat, which is defined by open water that provides access to foraging areas (Reid et al. 1994). Riparian areas adjacent to water also are important components of river otter habitat. One key factor is the riparian zone's attraction to beavers, who create lodges and dam pools that provide habitat for many prey of the otters. The dependence of river otters on beavers for both provision of den sites (abandoned beaver lodges) and creation of prime habitat (dammed pools) is noted by many researchers (Bradley 1994, Melquist and Dronkert 1987, Melquist and Hornocker 1983, Reid et al. 1994).



River otters have a low to moderate reproductive potential; they usually have a litter of three young but may not breed every year (Toweill and Tabor 1982). They usually mature sexually by age 2 and may live 10 to 15 years in the wild (Melquist and Dronkert 1987). Although no predator is documented as having significant impact on river otter populations, several carnivores are reported to have killed river otters; these include bobcats, coyotes, foxes, mountain lions, wolves, and black bears (Toweill and Tabor 1982).

River Otter Issues in the Basin

A rising concern for the conservation of aquatic, riparian, and wetlands habitats bodes well for the river otter throughout North America. Many wildlife agencies have conducted reintroduction programs for otters in recent years, as well (Melquist and Dronkert 1987). Counteracting forces, including habitat loss and water pollution, will continue to work against otter conservation; river otter fur has been highly prized by fur trappers for centuries, and trapping will continue to have direct impact on harvested populations. River otters are harvested in most states of the basin (appendix C). Three issues are of concern to river otter conservation and management in the basin.

Issue 1: Conservation of aquatic and riparian habitat—River otters cannot use relatively food-poor small mountain streams in forested areas of the Western United States and thus are dependent on adequate habitat along larger waterways. Beavers create important habitat features and suitable habitat (pools) for river otters, and conservation of this species will also benefit otters.

***Key environmental correlates*—**The following information is available on basin GIS:

- Rivers, lakes, estuaries, ≥3d order streams

The following information is not currently available on basin GIS:

- Water quality
- Coarse woody debris
  1. Large hollow logs
  2. Log piles
- Beaver density

Issue 2: Maintenance of links among populations—River otters have been documented as dispersing 42 km overland in Idaho (Melquist and Hornocker 1983). Barriers in the form of inhospitable habitat are not known. Although most movement of river otter in Idaho followed streams, ridges separating drainages also were traversed by otters carrying radio telemeters.

***Key environmental correlates*—**Because information is limited, there are no specific environmental correlates that can be used to monitor habitat for support links among otter populations at this time. It is possible that the presence of beaver and year-round open water might serve as correlates.

Issue 3: Trapping pressure and human disturbance—Human-related mortality causes include trapper harvest, road kills, accidental trapping, and poaching (Melquist and Dronkert 1987). Human activities that lead to water pollution also may impact river otters, both indirectly (through the food chain) and directly. Several studies have documented significant levels of mercury, DDT, and PCBs in river otters, and Henny and others (1981) believe that a decline in otter populations along the Columbia River in Oregon was caused by PCB poisoning.

***Key environmental correlates*—**The following information is available on basin GIS:

- Road density ≤1.6 km/2.6 km^2

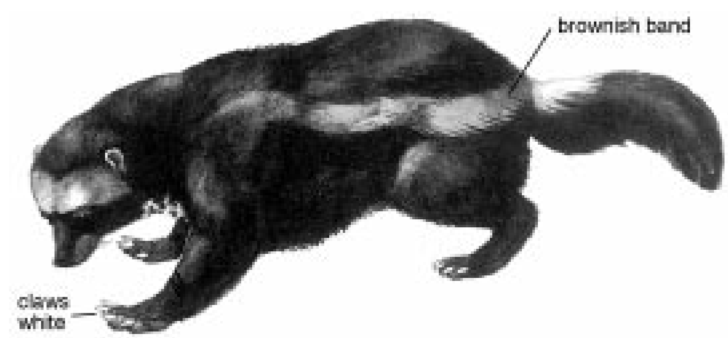
The following information is not currently available on basin GIS:

- Water quality
- Allowable river otter harvest by area

Wolverine (*Gulo gulo*)

Ecology

The wolverine is circumpolar in distribution, and is found in the arctic tundra and across forested Alaska and Canada in the north. The continental range of the wolverine extends through boreal montane habitats at the southern limits of its range in eastern and central Canada,



the Northwestern United States, and south along mountain ranges to Arizona and New Mexico (Hash 1987, Wilson 1982). Current range has receded from the historical extent of the species in North America, with notable declines in eastern Canada and the prairie provinces. In the Western United States and the interior Columbia basin, wolverines occur widely at very low densities, but only in northwestern Montana are wolverine populations considered to be healthy and thriving[5] (appendix A).

[5] Butts, T. 1992. Wolverine (*Gulo gulo*) biology and management: a literature review and annotated bibliography. 106 p. Unpublished report. On file with: U.S. Department of Agriculture, Forest Service, Northern Region, Federal Building, P.O. Box 7669, Missoula, MT 59807.

Reported home range sizes for wolverines generally are large. Wolverines are capable of sustained travel, and coverage of 30 to 60 km in a few days is documented (Wilson 1982). Home ranges for males in northwestern Montana averaged 422 km^2 and for females, 388 km^2 (Hornocker and Hash 1981). Lactating females in the same study had considerably smaller home ranges of 100 km^2. Similarly large home ranges of hundreds of square kilometers have been reported in Alaska (Magoun 1985). In a study in the Yukon, Banci (1987) found markedly smaller home ranges than in Alaska or Montana and theorized that the wolverines had localized access to adequate food and mates. Home range sizes of wolverines in Idaho were reported as 80-700 km^2 for females and more than 2000 km^2 for resident males.[6] Some researchers have found evidence of intrasexual territoriality in the wolverine (Magoun 1985, Powell 1979), but Hornocker and Hash (1981) found only temporal segregation of wolverines in Montana, with extensive overlap of home ranges.

A large proportion of the wolverine diet is a variety of ungulates, primarily taken as carrion (Banci 1987, 1994; Hash 1987; Rausch and Pearson 1972; Wilson 1982). Ungulate carrion seems to be particluarly important to wolverine diet in late winter and early spring. Wolverines also can kill ungulate prey, as well as smaller animals, including marmots and ground squirrels, and ptarmigan *(Lagopus spp.)* and other birds (Hash 1987, Magoun 1985, Wilson 1982). The noted importance of ungulate carrion to wolverines probably requires long scavenging treks and may be one factor leading to the large home ranges reported by researchers. Hornocker and Hash (1981) report that wolverine density was greatest in their Montana study area where ungulate diversity was highest. The same area also supported snowshoe hares, hoary marmots *(Marmota caligata)*, and a variety of small mammals. Winter range of wolverines was focused on ungulates winter range in the area.

[6] Copeland, J.; Harris, C. 1994. Wolverine ecology and habitat use in central Idaho. 26 p. Unpublished report. On file with: Idaho Department of Fish and Game, 600 S. Walnut, P.O. Box 25, Boise, ID 83707.

Many authors define wolverine habitat worldwide as boreal forest and tundra (Hash 1987, Wilson 1982). Wolverines occupy mixed coniferous forest habitats in coastal regions from southeastern Alaska to southern British Columbia, in the Cascade Range and Sierra Nevada, and in the Rocky Mountains (Hash 1987). The wolverine is found in boreal forest across Canada in middle and southern latitudes; tundra is the predominant vegetation type in the northern range of the species. The majority (70 percent) of locations of wolverines carrying radio telemeters in a study in Montana were in forests with medium to low canopy cover (Hornocker and Hash 1981). Wolverines selected forests dominated by subalpine fir (*Abies lasiocarpa* Hook. (Nutt.)), and rarely used dense young timber, burned areas, or wet meadows. Copeland and Hudak[7] report that wolverines in Idaho prefer mature montane forest in association with subalpine rock and scree habitats. Wolverines use a variety of habitat features as dens, including exposed tree roots, rock piles, caves, and log falls (see footnote 5). Female wolverines used subalpine talus sites for natal dens in Idaho (see footnote 6).

Wolverines are associated with remote areas with little disturbance by humans (Groves 1988, Hash 1987). Hornocker and Hash (1981) report that wolverines are reluctant to cross large openings, including clearcuts. Although wolverines reportedly avoid areas of human habitation, they may cross these areas during their travels, usually under cover of night (Hash 1987). Banci (1994) notes that wolverines feed at community garbage dumps in the Canadian north and that they occupy logged forests in British Columbia. Banci (1994) suggests that some as-yet-unknown combination of factors dictate wolverine presence, and lack of human activity alone is not adequate to define suitable wolverine habitat.

[7] Copeland, J.; Hudak, H. 1995. The wolverine (*Gulo gulo*) in Idaho: Habitat conservation assessment and conservation strategy. 21 p. Unpublished report. On file with: Idaho Department of Fish and Game, 600 S. Walnut, P.O. Box 25, Boise, ID 83707.

Wolverines have a low-to-moderate reproductive potential, reaching sexual maturity at 1 or 2 years of age and usually bearing a litter of two to three young per year (Wilson 1982). Poor breeding success and high juvenile mortality may contribute to low reproductive output (Hash 1987). Wolverines have no known natural predators, and the main causes of mortality are human-induced ones (Banci 1994, Hash 1987, see footnote 7). Wolverines probably benefit from predatory activities of other large carnivores and garner ungulate carrion from those kills. Some direct mortality of wolverines by wolves and mountain lions has been documented, but it likely is a minor mortality factor (Banci 1994, Hornocker and Hash 1981, see footnote 6).

Wolverine Issues in the Basin

In all states of the interior Columbia basin except Montana, the wolverine is legally protected from harvest because it is considered rare (see footnote 5). Montana continues to classify the wolverine as a furbearer, and an annual harvest is allowed. Total annual harvests over the past 30 years have averaged between 10 and 15 animals, with as few as 5 taken in one year (1991) and as many as 58 (1976). The USDA Forest Service considers the wolverine a sensitive species, with population viability a prime concern. The low densities of the wolverine and its dependence on remote habitat continue to make this species vulnerable to local and regional extinctions. Some authors suggest that there is no justification for any continued harvest of wolverines in the Lower 48 States because the minimal current harvest offers little economic or recreational return and only adds to negative pressures on the species (Wilson 1982, see footnote 5). Wolverine populations in northwestern Montana have a good probablility of persistence in the near future, because of their continuity with protected areas in Canada (Banci 1994). Populations in other areas within the basin, including Idaho and Oregon, are more isolated and thus more vulnerable to extinction. Three issues are of concern to wolverine conservation and management in the basin.

Issue 1: Maintenance of large, remote areas of habitat—The wolverine's dependence on suitable habitat in remote areas, with little or no human disturbance, is notable. Additionally, wolverines appear capable of repopulating habitat from suitable refugia (Allen 1987, Hash 1987). Banci (1994) suggests other, currently unknown, habitat factors act in concert with lack of disturbance to create optimal wolverine habitat, and our lack of knowledge is a critical problem for successful wolverine conservation. Successful habitat management for wolverines may actually involve managing for many prey species on which wolverines depend, and Butts (see footnote 5) noted that wolverine conservation requires ecosystem conservation. A wide variety of habitat types, supporting a variety of ungulate, small mammal, and avian prey, therefore are necessary for viability of individual, and populations of, wolverines.

Maintenance of forested areas within wolverine habitat will be necessary to provide security cover; travel corridors between such areas should be provided. Any activities affecting or altering montane boreal habitats may have negative impacts on wolverines (see footnote 7). Many types of habitat alteration have probably reduced the quality of or eliminated wolverine habitat, including agriculture, cattle grazing, forestry, oil exploration, human settlement, and human population growth (Banci 1994). The impression that wolverines require high-altitude habitat may be caused by the remaining wolverines in populations stressed by human activities retreating to the least accessible, currently undeveloped territory, which is often at high elevations.

Little is known about the continuity or fragmentation of wolverine populations south of Canada, and little information exists on potential barriers to movements (see footnote 7). In this vacuum of knowledge, there is a high probability that habitat alteration will negatively impact persistence of wolverine populations. If populations become isolated, susceptiblity to local extinction increases. Wolverines have low birthrates, with low percentages of females becoming pregnant each year and small litter sizes (Banci 1987, Hash 1987, Hornocker and Hash 1981, Magoun 1985, Rausch and Pearson 1972). Low reproductive output contributes to the vulnerability of wolverine populations to local extinction.

Recreational development in mountainous areas may be especially injurious to wolverine conservation. In Idaho, subalpine cirques have been identified as key areas for wolverines because of their use for natal denning (see footnote 7). Ski area development in particular poses a threat to wolverines, because use of these cirques for recreational purposes would make them unavailable for isolation-dependent wolverines.

***Key environmental correlates*—**The following information is available on basin GIS:

- Habitat types
  1. Alpine and subalpine types
  2. Coniferous forests
- Wilderness and large roadless areas
- Human density

The following information is not currently available on basin GIS:

- Coarse woody debris
  1. Large snags
  2. Large logs
  3. Log piles
- Rocky habitat
  1. Scree and talus slopes
  2. Caves
- Trail density
- Off-road motorized vehicle areas
- Rural homesite density
- Recreational developments
- Back-country campgrounds
- Oil, gas, and mining exploration and extraction sites

Issue 2: Prey populations—Areas of high ungulate density, and especially winter range, are probably key in identifying suitable wolverine habitat in mountainous regions. Activities that decrease ungulate density may negatively impact wolverines (Banci 1994); these include excessive hunter harvest and poaching and habitat alteration that decreases quality for ungulates. Livestock losses on grazing allotments may provide carrion sources for wolverines (see footnote 7).

***Key environmental correlates*—**The following information is available on basin GIS:

- Grazing allotments

The following information is not currently available on basin GIS:

- Ungulate density and winter range areas
- Ungulate harvest by area

Issue 3: Incidental trapping and predator control mortality—Wolverines are easily attracted to lures and baits and, thus, may be subject to injury or direct mortality as a nontargeted species on trap lines set for species of similar or larger size than wolverines (see footnote 7). It is thought that all or most of the recent legal harvest of wolverines in Montana has been incidental take in traps set for other species (Banci 1994). Additionally, use of sodium cyanide in M-44 delivery systems for coyote control (Green et al. 1994) may unintentionally impact wolverines.

***Key environmental correlates*—**The following information is not available on basin GIS:

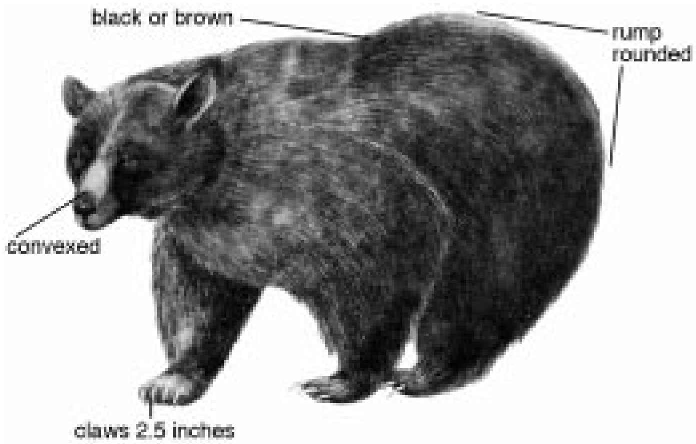
- Areas and target species of legal harvest
- Areas under predator control with sodium cyanide

Black Bear (*Ursus americanus*)

Ecology

Black bears range throughout much of eastern and western North America, especially in forested areas of rugged topography (Kolenosky and Strathearn 1987, Pelton 1982). Historically, they have been considered a pest and a threat to human life and property and, hence, were extirpated or reduced to very low numbers in many Eastern and Midwestern States (Pelton 1982). They are considered common in the Pacific Northwest, Rocky Mountains, and all Canadian provinces. They occur throughout the interior Columbia basin except for the open, semiarid Columbia basin plateau (appendix A).

Home range sizes are variable, from 10 to over 100 km^2 (Kolenosky and Strathearn 1987, Pelton 1982). Black bears are long-lived (20+ years) and usually use the same areas throughout their lives (Amstrup and Beecham 1976). Except for sows with cubs, bears are solitary, so densities are usually low, about one bear per 2 to 14 km^2 (Pelton 1982). Densities and home range sizes are closely related to food availability.



Black bears are omnivores and their diet varies seasonally (Kolenosky and Strathearn 1987, Pelton 1982). In spring, they feed on grasses, carrion, and in some areas, on the cambium layer of trees. They feed on young ungulates and livestock as well. In summer and fall, they feed on forbs and the fruits of various trees and shrubs. They also consume insects when concentrated sources are available. Bears must put on substantial weight to survive the 5- to 6-month winter hibernation. Consequently, they spend much time in energy-rich (high fat and carbohydrate levels) areas such as berry patches, meadows, avalanche chutes, riparian areas, garbage dumps, and sites where colonial insects occur (Elowe and Dodge 1989). Thus, a close relation exists among habitat use, movements, and behavior by the bears, and plant phenology (Amstrup and Beecham 1976, Rogers 1987).

Black bears use a variety of habitats but prefer a mix of forested and open areas (Kolenosky and Strathearn 1987, Pelton 1982). Open areas with mesic vegetation are used for foraging, as are areas with thick, brushy understories and berries or other mast (Unsworth et al. 1989). Bed sites are usually in uncut forest stands: coniferous, mixed, or aspen stands (Irwin and Hammond 1985, Unsworth et al. 1989). Black bears avoid rock talus areas and sagebrush-grass areas.

Den sites are important for bear survival. Uncut forest is used and most dens are excavated in the ground or under the roots of fallen trees (Tietje and Ruff 1980). Large-diameter snags or downed logs also may be used (Pelton 1982, Tietje and Ruff 1980).

Black bears are fairly adaptible and can coexist with humans if the bears are not overharvested (Kolenosky and Strathearn 1987, Pelton 1982). In most cases, hunters are the main source of bear mortality. Bears are active mostly from dusk until dawn, thereby minimizing contact with humans (Amstrup and Beecham 1976, Pelton 1982). Conflicts are more likely to occur when natural food sources are poor (Pelton 1982).

Bears have a low reproductive potential. Females do not have their first litter until they are 3 to 6 years old; typically, a litter of two to three cubs is born every 2 to 5 years (Pelton 1982, Rogers 1987). Cub mortality rates are often 40 to 50 percent, and this increases to about 60 percent for subadults, especially males (Elowe and Dodge 1989). Young bears can die from several causes, but many are killed by adults bears as the young disperse and attempt to establish a territory (Kolenosky and Strathearn 1987, Pelton 1982, Schwartz and Franzmann 1991). Mortality rates are highest in poor food years (Kolenosky and Strathearn 1987, Schwartz and Franzmann 1991). Bears compete with other forest carnivores for carrion and prey (young ungulates and livestock). They may be killed or driven off by grizzly bears or wolves (Gehring 1993, Schwartz and Franzmann 1991, Smith and Follmann 1993, Veitch et al. 1993).

Black Bear Issues in the Basin

Black bears are widespread and relatively common in the Western United States, although overharvest by humans is a concern in some areas. Black bears require certain habitats and habitat elements to do well, but at higher densities, they can come into conflict with humans, especially when humans encroach on bear habitats. Two issues are of concern to black bear conservation and management in the basin.

Issue 1: Provision of appropriate habitat mix—Black bear populations thrive where there is a mix of forested areas and small openings that provide foraging sites. Intrusions by roads or human activities must be minimal. Large woody debris and snags should be left to provide foraging and denning opportunities along with caves and talus slopes (Kolenosky and Strathearn 1987). Steep, north-to-northeast-facing slopes are important denning areas (McCutchen 1993). Riparian habitats, meadows, bogs, and valley bottoms can be especially important foraging areas and need protection from human development and heavy use.

Key environmental correlates—The following information is available on basin GIS:

- Forest cover, structure, interspersion
- Riparian habitat, valley bottoms
- Physiography (slope, aspect)
- Ungulate ranges

The following information is not currently available on basin GIS:

- Ungulate density
- Coarse woody debris, log piles
- Meadows, bogs
- Rock outcrops, caves

Issue 2: Reduction of conflicts with humans—Black bears will use easily accessible, high-energy food sources, so humans must exercise caution with garbage dump sites and food storage in the backcountry (Merrill 1978, Payne 1978). Backcountry users should be instructed on appropriate actions and behaviors around black bears (Bromley et al. 1992). Roads, campgrounds, homes, and recreational developments may bring humans into contact with bears. Hence, access to—and human development in—areas of high black bear densities should be minimized to reduce conflicts.

Key environmental correlates—The following information is available on basin GIS:

- Road density
- Human density

The following information is not currently available on basin GIS:

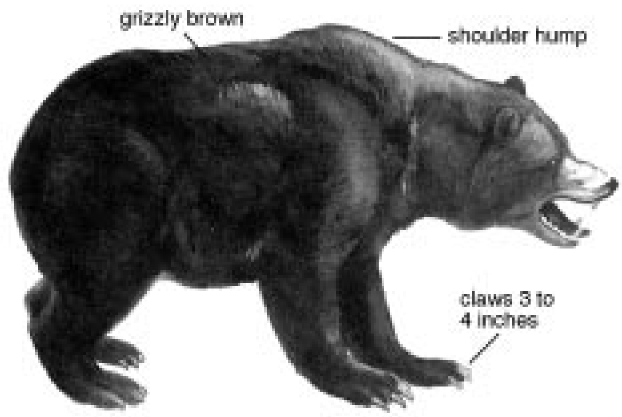
- Trail locations, density
- Campgrounds
- Recreational developments
- Garbage dumps, landfills

Grizzly Bear (*Ursus arctos*)

Ecology

Grizzly bears once were widespread in North America, but their current range and numbers are only about 1 percent of historical levels (Jonkel 1987, USFWS 1993). The large size of bears and aggressive encounters with humans and their livestock resulted in the extirpation of grizzly bears from much of their historical range (Craighead and Mitchell 1982). Small populations (in total, about 250 bears) exist in small areas of the interior Columbia basin—but primarily in the north Continental Divide and Yellowstone ecosystems—where they are protected under the Endangered Species Act (appendix A; Jonkel 1987, USFWS 1993). Their range and numbers are much larger in western Canada and Alaska, where grizzly bears are still harvested in regulated seasons (Horejsi 1989, Jonkel 1987).

Grizzly bears require large territories because of their size and food requirements. Home range sizes of 1400 to 3757 km^2 (males) and 285 to 884 km^2 (females) are reported (Craighead and Mitchell 1982, Servheen 1983). Home ranges can be much smaller and can overlap, especially in good habitat or at good foraging sites (Jonkel 1987).



Grizzly bears are omnivorous and generalist feeders (Craighead and Mitchell 1982, USFWS 1993). They need to consume large amounts of high-energy (fats, carbohydrates) and high-protein foods before their 5- to 7-month winter hibernation (Blanchard and Knight 1991, Craighead and Mitchell 1982, Jonkel 1987). Their movements and habitat use patterns are closely associated with available food sources and plant phenology (Servheen 1983). In spring, grasses and carrion are used; in summer, grasses, forbs, and ferns are used; in fall, tree and shrub fruits, insects, and grasses are used. Ground squirrels and other burrowing animals may be used, especially in spring (USFWS 1993). Ungulates and livestock (both adult and young) can be important elements of the diet when and where available (Peek et al. 1987). Grizzly bears may influence population sizes of elk and moose (Ballard 1992, Cole 1972, Larson et al. 1989).

Grizzly bears use a diversity of habitats that provide for travel, security, foraging, and denning (Jonkel 1987). They also require habitats that provide a local abundance and sequential availability of foods. Areas for foraging (open forest, riparian areas, lakeshores, seeps, meadows, avalanche chutes) interspersed with areas of forest cover for security and bedding are essential (Agee et al. 1989, Servheen 1983, USFWS 1993). Even-aged, second-growth stands with minimal understory development provide poor habitat (Peek et al. 1987). These areas must be relatively free from disturbance and human activities (Knight et al. 1988, McLellan and Shackleton 1988). Most grizzly bears avoid roads and recently logged areas (Peek et al. 1987). Whitebark pine *(Pinus albicaulis E*ngelm.; for seed production), subalpine larch *(Larix lyallii* Parl.), and subalpine herbaceous habitats are important to grizzly bears (Agee et al. 1989, Blanchard and Knight 1991). Additionally, denning sites are very important: typically, winter dens are excavated on steep, north-to-northeast slopes above 1370 m in elevation where deep snows accumulate and human activity and development does not occur (USFWS 1993).

Grizzly bears are generally long-lived (20+ years), but they have a low reproductive potential. Typically, females do not reproduce until they are 5+ years old and produce only about two cubs every 3+ years (Craighead and Mitchell 1982, Jonkel 1987). Natural mortality of bears is relatively low, and humans account for most adult grizzly bear mortality (Peek et al. 1987, Wielgus et al. 1994). Additional mortality occurs from disease, accidents (especially through poor choice of denning sites), old age, malnutrition, and infanticide by adult grizzly bears (Jonkel 1987, Olson 1993). To maintain or increase populations, it is especially important to protect females with cubs (Knight and Eberhardt 1985, Sidorowicz and Gilbert 1981). Grizzly bears compete with other forest carnivores for food, including carrion (LaFranc 1987). There are some reports of grizzly bears killing or displacing black bears and wolves from carcasses or by excavating dens (Haynes and Baer 1992, LaFranc 1987, Smith and Follman 1993).

Grizzly Bear Issues in the Basin

Grizzly bears are dominant forest carnivores once widespread in the Western United States. Conflicts with humans greatly reduced their numbers and range, and these conflicts continue today. The bears have specific habitat requirements that can limit their numbers and range even with reductions in human-caused mortality. Their occurrence in the basin is very limited except for the far eastern fringe (western Montana and northwestern Wyoming). Three issues are of concern to grizzly bear conservation and management in the basin.

Issue 1: Provision of habitat needs—Sustaining a population of grizzly bears requires a very large (10 000+ km^2) area of appropriate habitat. Appropriate habitat is a mix of closed canopy forest interspersed with openings. Natural openings, such as avalanche chutes, meadows, riparian areas, and shrubby areas, are appropriate for foraging and for providing sequential food availability. Whitebark pine and subalpine larch stands are important forest cover types, probably because their open canopy nature provides foraging opportunities while maintaining adequate security cover. Coarse woody debris, snags, log piles, and caves are important habitat elements. Steep, rocky, north-to-northeast facing slopes are important denning areas. Human developments in—and human use of—important grizzly bear areas should be avoided to reduce human-caused mortality and competitive use of habitats. Relatively few areas will meet these requirements, but several are identified in the "Grizzly Bear Recovery Plan" (USFWS 1993; also see LaFranc 1987).

Key environmental correlates—The following information is available on basin GIS:

- Wilderness areas and large roadless areas
- Forest cover, structure, interspersion
- Physiography (slope, aspect, elevation)
- Riparian habitat
- Ungulate ranges

The following information is not currently available on basin GIS:

- Ungulate densities
- Burrowing rodent ranges, densities
- Coarse woody debris, log piles
- Meadows, avalanche chutes, shrub fields
- Caves

Issue 2: Prevention of subpopulation isolation and extinction—Grizzly bears occur in only a few, small, isolated areas of the basin. Four of these small populations (north Cascades, Selkirks, Cabinet-Yaak, and northern Continental Divide) may have links with Canadian populations, although the amount of interchange of bears is not known (USFWS 1993). The other two areas (Selway-Bitterroot and Yellowstone) are much more isolated. The continued viability of the two sustaining populations (northern Continental Divide and Yellowstone) and the restoration of populations in the other four areas may depend on occasional immigrant bears from adjacent populations to counteract mortality in the local population and to help maintain genetic viability (Paquet and Hackman 1995). Consequently, it is important to maintain linkage zones or corridors between populations of bears in designated recovery areas and across the border between the United States and Canada. This would facilitate the occasional movement of dispersing bears among populations. Unfortunately, discussions (e.g., Craighead and Mitchel 1982, Jonkel 1987, Paquet and Hackman 1995) of links and corridors do not give specific attributes for defining effectiveness. Possible links among the six areas of the basin mentioned above are discussed by the USFWS (1993). Extensive development and intensive land uses may limit the effectiveness of potential links. Additionally, highways may form barriers to dispersal and increase bear mortalities (Paquet and Hackman 1995).

Key environmental correlates—The following information is available on basin GIS:

- Potential links and corridors (between recovery areas)
- Highways

The following information is not currently available on basin GIS:

- Integration of habitat and other GIS data bases from Canada and United States sources

Issue 3: Reduction of conflicts with humans— Where grizzly bears and humans coexist, there will be conflicts and occasional fatalities of both (Peek et al. 1987). It is best to restrict most human developments and human uses in—as well as livestock access to—designated grizzly bear recovery areas (Knight et al. 1988, Peek et al. 1987). Backcountry use should be regulated and users should be instructed on appropriate actions and behaviors and food storage in grizzly bear areas (Bromley et al. 1992). Artificial food sources, such as open garbage dumps, should not be allowed in or near grizzly bear areas (Martinka 1974, Merrill 1978). Road densities should be low, preferably <1.6 km/2.6 km^2 of habitat in grizzly bear areas (LaFranc 1987, McLellan and Shackleton 1988, Peek et al. 1987, USFWS 1993). A cooperative and consistent nuisance bear control program also is important (USFWS 1993).

Key environmental correlates—The following information is available on basin GIS:

- Road density
- Human density

The following information is not currently available on basin GIS:

- Livestock grazing areas, densities
- Trail locations, densities
- Campgrounds
- Recreational developments
- Homesite locations, density
- Off-road motorized recreational vehicle use areas
- Garbage dumps, landfills

Conclusions

The long-term conservation of a representative carnivore community in the interior Columbia basin is problematic at best (Clark et al. 1996b, 1996c; Kucera and Zielinski 1995; Noss et al. 1996; Ruggiero et al. 1994). Carnivores, particularly the large carnivores, present unique conservation problems that will be difficult to solve. The large size of many of these far-ranging species, along with their variable specific habitat and prey base needs, their differing statuses, and the diverse management approaches used by the states (summarized in appendices B, C, and D) all add to the challenge presented. Grizzly bears, gray wolves, and mountain lions are viewed negatively by a portion of the public because of perceived and real dangers to human safety, economic impacts from livestock depredations, and negative impacts on game populations (Andelt 1996, Kellert et al. 1996, Witmer et al. 1995). Regardless of legal status and level of protection, illegal and accidental killing (e.g., highway mortality) of large carnivores can have a significant impact on survival and population growth, especially when many of the species have low-to-moderate reproductive potential. The long-term survival of large carnivores therefore rests on developing and implementing a much broader landscape-level conservation plan to provide large, remote, or relatively inaccessible areas for protection from human impacts and disturbance (Noss et al. 1996, Primm and Clark 1996, Servheen and Sandstrom 1993, Weaver et al. 1996). Management policy for large carnivores needs to recognize human emotional reaction to these animals and incorporate strategies to mitigate potential impacts posed by negative public attitudes, especially toward large carnivores (Clark et al. 1996b, Kellert et al. 1996, Primm and Clark 1996).

The management hypothesis that needs to be tested for the basin is that large carnivores can coexist successfully with humans if the carnivores are provided with enough core areas, linked with connecting habitats, to maintain productive populations which can persist over long periods and inevitable environmental fluctuations. For nearly all species, there is a knowledge vacuum concerning minimum viable population sizes and population sustainability (Noss et al. 1996, Salwasser et al. 1984). Habitat conservation plans must be enacted for carnivores in the basin before we have definitive information on population viability and the role of metapopulation structure.

Smaller carnivores generally do not face such highly negative public attitudes but, nonetheless, have their own conservation challenges and susceptibility to human impacts. Species such as the marten and fisher require conservation of late successional forests. Wolverines may be affected by increasing human disturbance and use of subalpine communities and accidental mortality from trapping. Lynx require early seral stage boreal forest habitats supporting large populations of snowshoe hare and other small mammals. Regulated harvest, incidental mortality from trapping, illegal harvest, and roads may limit lynx populations, especially during critical periods when prey are reduced. The river otter is a habitat specialist dependent on riparian areas supporting clean rivers and streams with productive fish populations. Extensive degradation of water quality and riparian communities has hurt this species. On the other hand, large, remote areas with very limited human activities and human-caused mortality and a large measure of human tolerance are required if the larger forest carnivore species—gray wolf and grizzly bear—are to continue to exist in the interior Columbia basin.

Some generalist carnivores are of more concern because they are highly successful and therefore may cause secondary negative impacts on other carnivores through competition. Coyote populations have been favored by the eradication of other large carnivores, extensive modification of habitats, human settlement, and disturbance (Quigley and Hornocker 1992, Witmer and Hayden 1992). High coyote populations may have negative consequences for recovering populations of wolves and other carnivores via competition for prey and carrion. High coyote population densities and their depredations also may lead to increasing demand for predator control programs (USDA 1994). Similarly, high bobcat population densities may have negative effects on lynx because of competition for prey and the more aggressive behavior of bobcats (Quinn and Parker 1987). Black bear population densities are high in many areas and, under such conditions, may lead to conflicts with humans, especially with human and livestock encroachment into bear habitats and the availability of artificial food sources. The problem can become more severe where bears are not adequately harvested by humans to help lower bear densities and to maintain their wariness of humans and human habitations.

Integrated Species Management

This technical analysis of 11 selected carnivore species in the basin revealed several conservation themes encompassing many species, although there was important variation among the overall species group (appendices A-D). The themes benefiting several species of carnivores are as follows:

- Conservation of late successional forest
- Preservation of large, remote, or inaccessible blocks of habitat with restricted human development and access
- Preservation or development of lower elevation riparian and forest habitats acting as connecting links between regional source populations
- Maintenance of adequate prey populations
- Reduction and management of negative interactions with humans to reduce availability of artificial food sources, highway mortality, illegal and accidental killing, the need for predator control, and the accidental take of nontargeted carnivores during harvest seasons or predator control operations.

The practical implementation of these conservation themes for carnivores requires land management on a larger scale than historically practiced by any Government agency. On-the-ground implementation of management plans for many species of carnivores, especially the larger species, requires coordinated actions among different state and Federal agencies, tribes, private landowners, and neighboring countries (Clark et al. 1996a, Mattson et al. 1996, Servheen and Sandstrom 1993). The formation of working groups with representation by diverse constituencies are a step in the right direction (Kucera and Zielinski 1995, Servheen and Sandstrom 1993). There must be effective cooperation between Canada and the United States to maintain habitat links and source populations for some species, such as the lynx, wolverine, grizzly bear, and gray wolf (Paquet and Hackman 1995). These links also would help maintain healthy genetic variation among subpopulations (Forbes and Boyd 1996, Weaver et al. 1996). At present, cooperation and coordinated planning between the United States and Canada mainly involve grizzly bear and wolf management; this effort needs to be expanded to include other carnivore species. Some specific land management actions that will help develop improved habitat and population management for carnivores include:

- Reduced development and use of roads
- Reduction in habitat fragmentation

Increasing development and use of roads, including both forest roads and highways, stand out as primary factors affecting carnivores (McLellan and Shackleton 1988, Mech et al. 1988, Paquet and Hackman 1995, Thurber et al. 1994). Increased human access to remote areas can result in higher mortality from hunting, illegal killing, and accidental deaths among many carnivores. Highways also act as significant barriers to movements for some species, although the impacts of roads and other barriers to animal movements are not well documented in ways that improve understanding of carnivore population dynamics. Reduced development, closure after use, and management of roads in forest and riparian environments are critical to carnivore conservation. Large carnivore populations have difficulty persisting when road access and interactions with the public exceed threshold levels. Studies of wolves and grizzly bears suggest that reducing the number of roads in forest environments is important to the maintenance of normal habitat use patterns and to lower human-caused mortality.

Development and Use of GIS Models for Carnivores

Geographic Information Systems have the potential to be useful in carnivore management by helping to identify and visualize critical and potential habitats and changes in habitats, and to facilitate long-term management planning (Agee et al. 1989, Servheen and Sandstrom 1993). Although many advantages of using GIS in landscape-level planning are evident, current GIS systems have some shortcomings for conservation planning and carnivore management. Improvements, discussed below, will greatly increase the value of GIS systems in carnivore conservation and management.

Many potential environmental attributes useful in carnivore management are not measured at all, are not routinely available on GIS systems, or are not available at the appropriate scale. Carnivores depend on prey species that fluctuate in distribution and abundance. Information on prey species is not routinely available or input into GIS-aided planning for forest management. Given the opportunistic—and often heavy use of—ungulate prey and carrion by carnivores, information on actual or potential ungulate population densities and distributions should be a high priority in GIS modeling. Interactions with humans are the most important cause of mortality for many carnivores. Consequently, increased measurement of variables reflecting human use and impacts on habitats should be considered as well. These might include campground locations, trails, recreational developments, homesites, landfills, and livestock grazing allotments. This information would be invaluable to many aspects of natural resource planning and environmental impact assessment. Additionally, many microsite habitats (<0.40 ha) are important to forest carnivores, but these are rarely incorporated into GIS systems.

Identification of actual or potential carnivore habitat by GIS does not translate into concrete information about population dynamics. At present, there is little understanding of the landscape-level population dynamics of carnivores and their prey (Peterson 1988, Quigley and Hornocker 1992). Methods of accurately and economically assessing presence, abundance, and population trends still are not available for most carnivore species (Ruggiero et al. 1994). Current efforts to better document forest carnivore presence by remote photography and track identification are a step in the right direction (Zielinski and Kucera 1995). Furthermore, the conceptual basis for managing populations at landscape levels is not supported by factual information on metapopulation dynamics. Design and subsequent use of corridors or habitat links by carnivores and other wildlife require technical information on movements, reproduction, survival, and cover use, which generally do not exist (Beier 1993, Harrison 1992, Servheen and Sandstrom 1993, Simberloff and Cox 1987).

Canada is an important source of individuals dispersing into the United States for some carnivore species (e.g., grizzly bears, lynx, wolverines, wolves), and GIS systems on both sides of the border should be integrated so that critical management information can be shared (Forbes and Theberge 1996, Paquet and Hackman 1995, Servheen and Sandstrom 1993). At present, carnivores effectively "drop off the edge of the world" when GIS modeling does not cross political boundaries of the United States and Canada. These situations and problems need to be addressed for GIS models to be more effective in carnivore management.

Coexistence and Competition Among Carnivores

At present, given the highly restricted distributions of many carnivores, it is difficult to assess the consequences of competition and predation among different carnivore species. A full assemblage of carnivores currently exists in northwestern Montana, Yellowstone, and possibly in the north Cascades, and it may be that in areas of adequate size, with low levels of human impacts, carnivore communities can still manage to persist and coexist in the United States. The detrimental consequences of species interactions (such as grizzly bears killing wolf pups or black bears, wolves killing mountain lions, or competition for food) do not seem to be nearly as important in carnivore management as is reducing the impacts of the primary carnivore predator—humans. Food habits overlap extensively for many of the larger carnivores and they rely on carrion, particularly during critical periods of winter and early spring. Maintaining adequate ungulate populations is pivotal to sustaining a full complement of large carnivores. Coexistence among carnivores may mean lower population levels for some individual species, because of negative interactions and competition for prey and carrion on population levels. These results are not certain, however, and more information needs to be gathered on predator-to-predator interactions (Peterson 1988, Quigley and Hornocker 1992). The dynamics of natural processes that produce carrion, including disease and predation, are not well-documented aspects of carnivore and wildlife ecology, and the physical and ecological attributes of regions supporting full complements of carnivores aren't either. The development of a carnivore research center, such as that proposed for the northern Rocky Mountain region, would provide the opportunity for large-scale, long-term field research in an area where many forest carnivore species coexist (Paquet and Hackman 1995, Ruggiero et al. 1994).

Reduction of Human Impacts on Carnivores

Without doubt, the most important single factor affecting all carnivore species is negative human impacts through habitat alterations or direct mortality (Clark et al. 1996a, 1996c; Kellert et al. 1996; Mattson et al. 1996; Paquet and Hackman 1995; Peterson 1988). Reduction of human-caused mortality is a primary concern in carnivore management. In some cases, better harvest management is required to assure that carnivore populations are not detrimentally affected by consumptive uses (Keiter and Locke 1996, Ruggiero et al. 1994). Individuals of a rare species, such as the wolf or wolverine, may be harvested incidentally to the intended harvest of a more common species, such as the bobcat or coyote. In this situation, regulations, harvest restrictions, or alternate harvest methods may be needed to reduce or prevent this occurrence. Management programs, including better education and communication, to reduce carnivore conflicts with livestock producers are required to lessen the need and impacts of predator control programs (Andelt 1996, Niemeyer et al. 1994, Witmer et al. 1995). Livestock grazing on public lands is a highly emotional and sensitive issue in the West, but the full consequences of trying to satisfy all demands on public lands is a critical problem in carnivore management. Large carnivores, in particular, depend heavily on large blocks of public lands for their future existence. If managers desire to maintain or enhance carnivore populations, programs to reduce conflicts between people and carnivores will help offset the negative attitudes towards carnivores among livestock producers and other segments of the public. Illegal and accidental killing of carnivores can be most effectively managed by influencing the amounts and types of human access to critical carnivore habitats and regions. Research to reduce the impacts of predators on humans and their valued resources continues in an effort to develop effective, cost-efficient, safe, and sociopolitically acceptable solutions (Andelt 1996, Fall 1990, Witmer et al. 1996).

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English Equivalents

When you know:	**Multiply by:**	**To find:**
Centimeters (cm)	0.39	Inches
Meters (m)	3.28	Feet
Kilometers (km)	0.62	Miles
Square kilometers (km^2)	0.39	Square miles
Hectares (ha)	2.47	Acres
Kilograms (kg)	2.21	Pounds (avdp)

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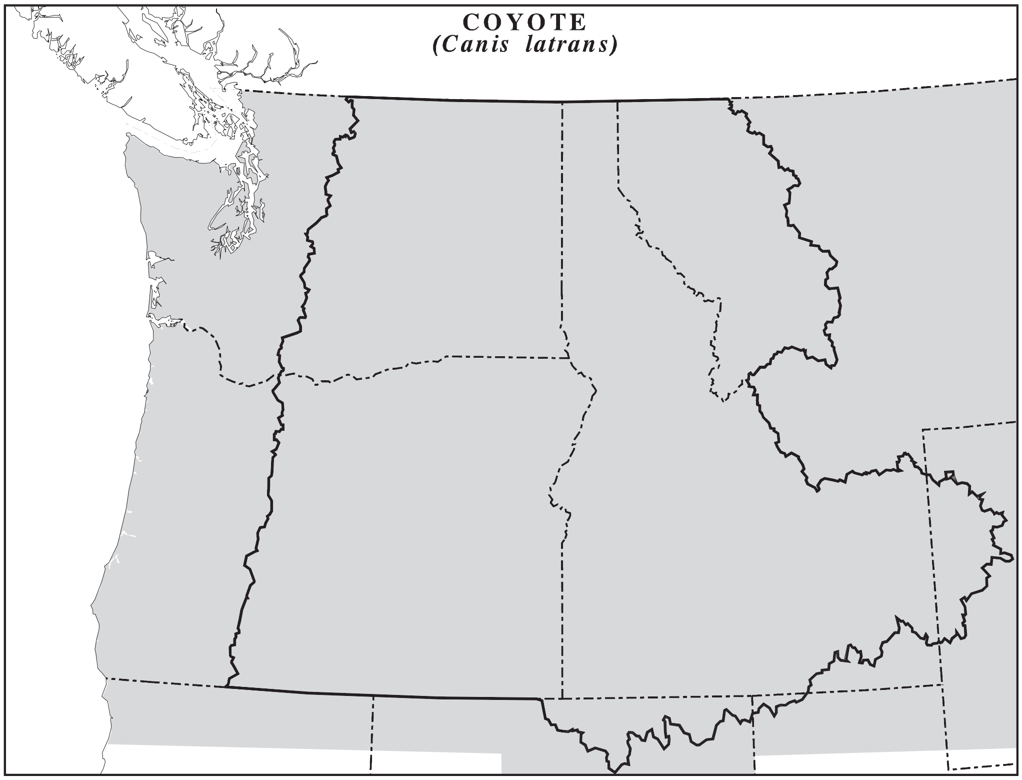
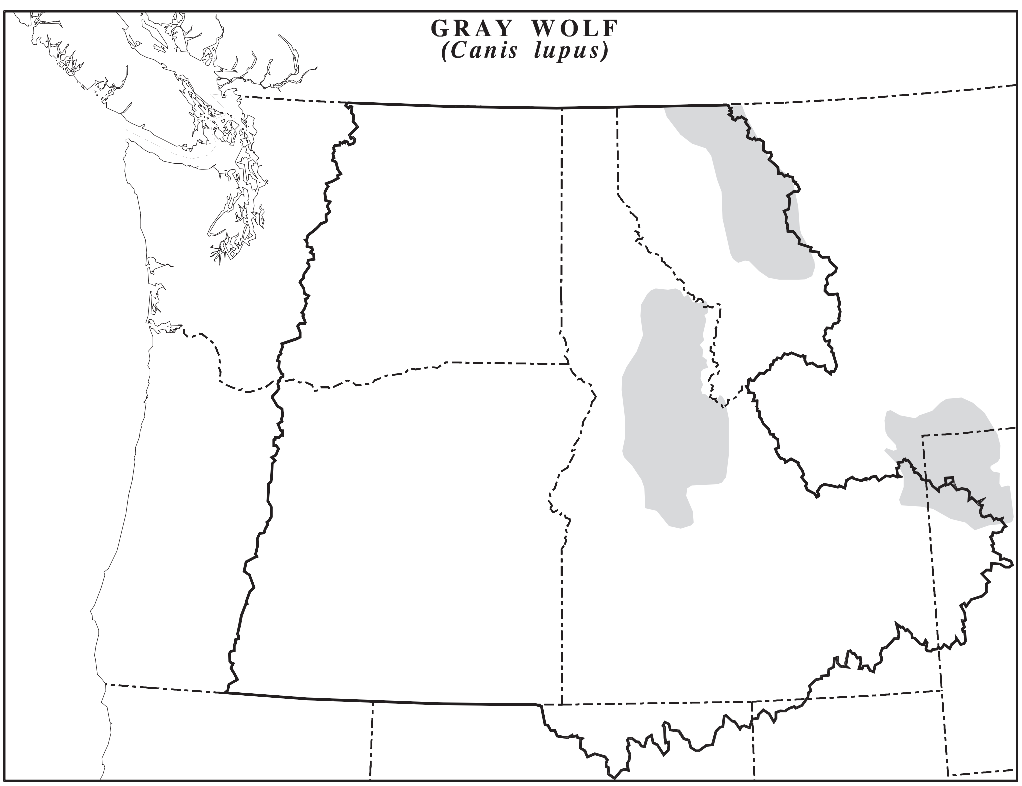
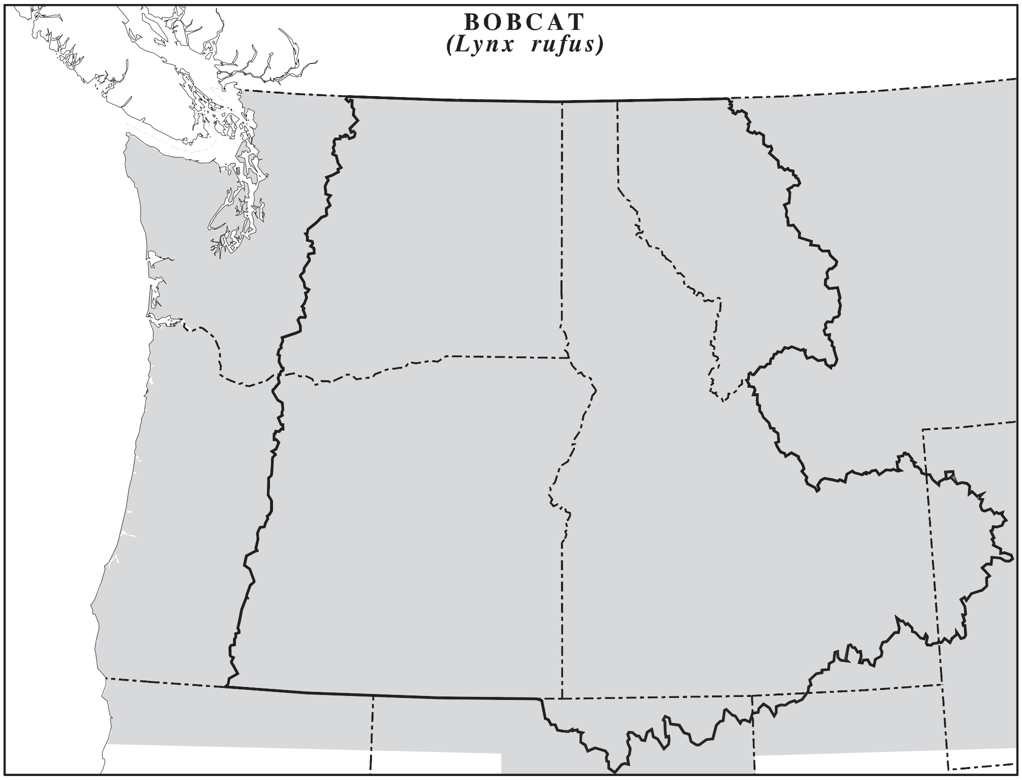
Appendix A
Species Range Maps

Solid line delineates interior Columbia basin; some range maps cover only the interior Columbia basin.



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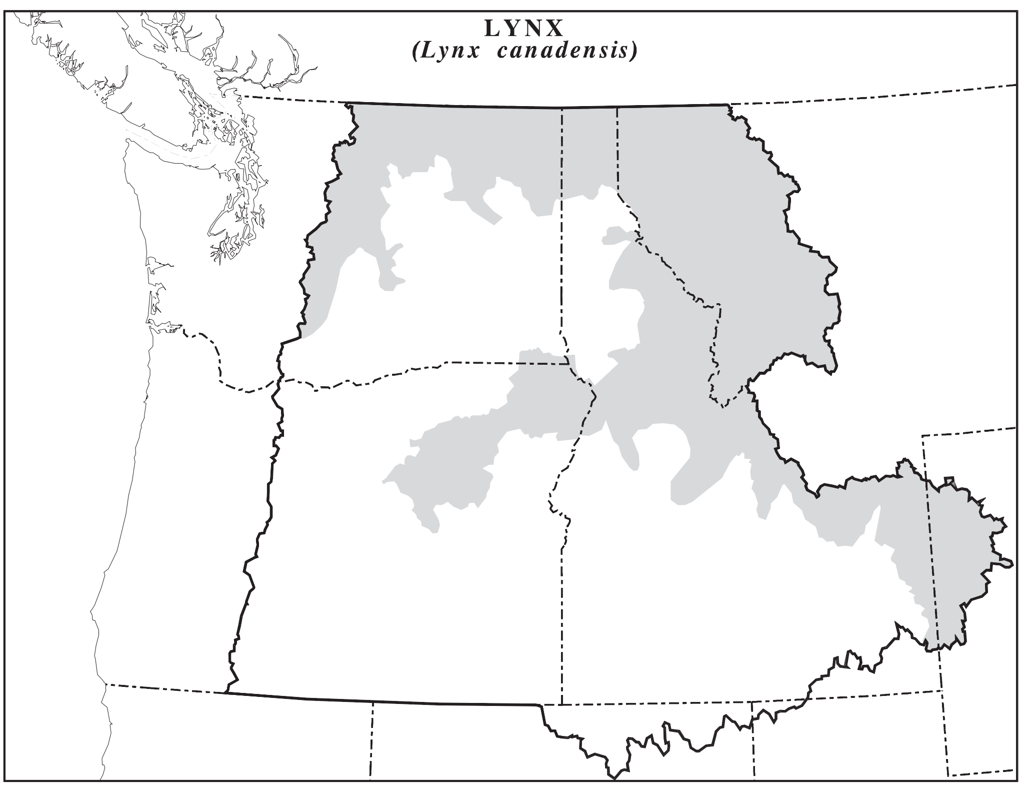
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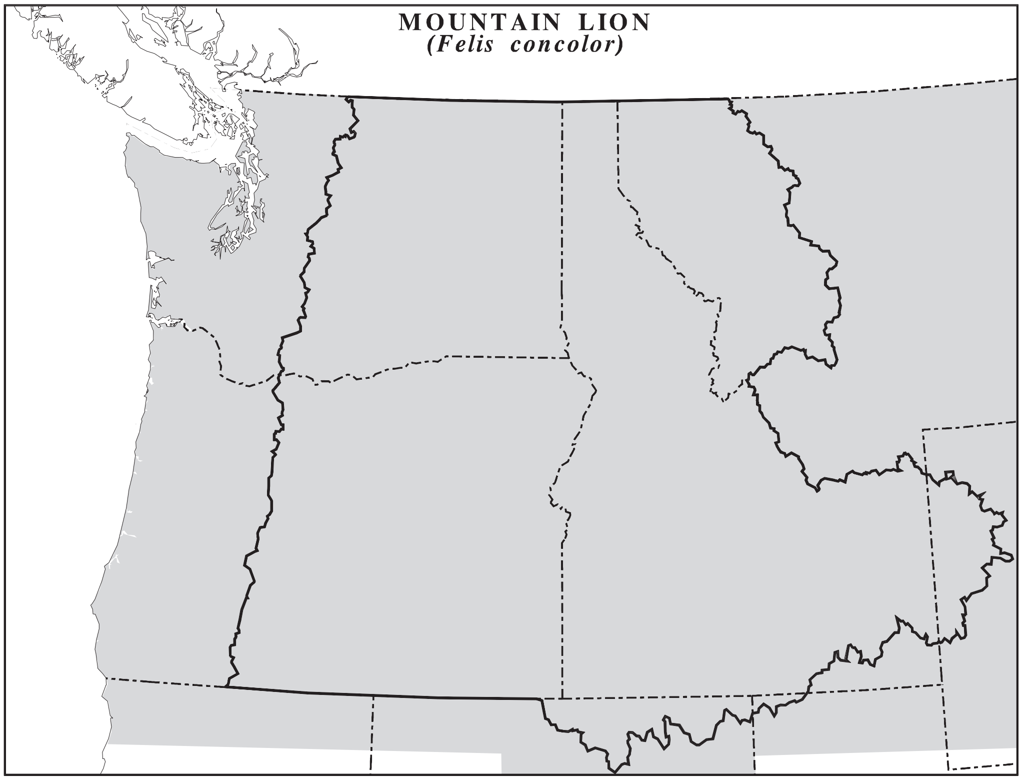
(Lynx canadensis)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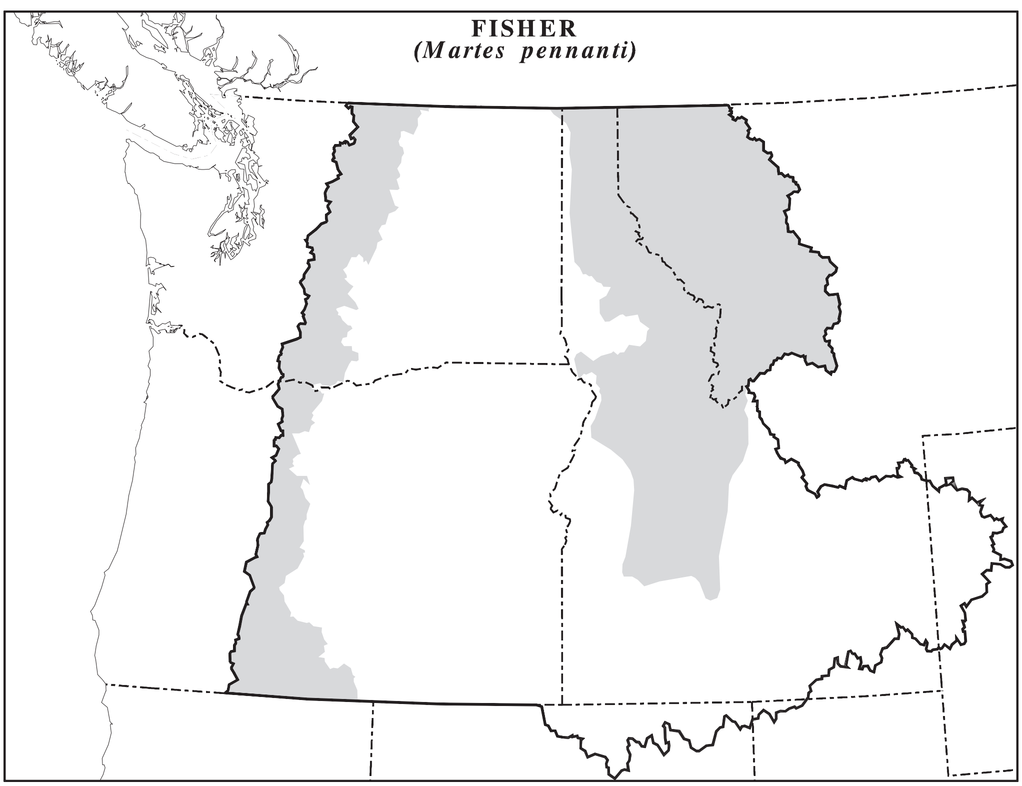
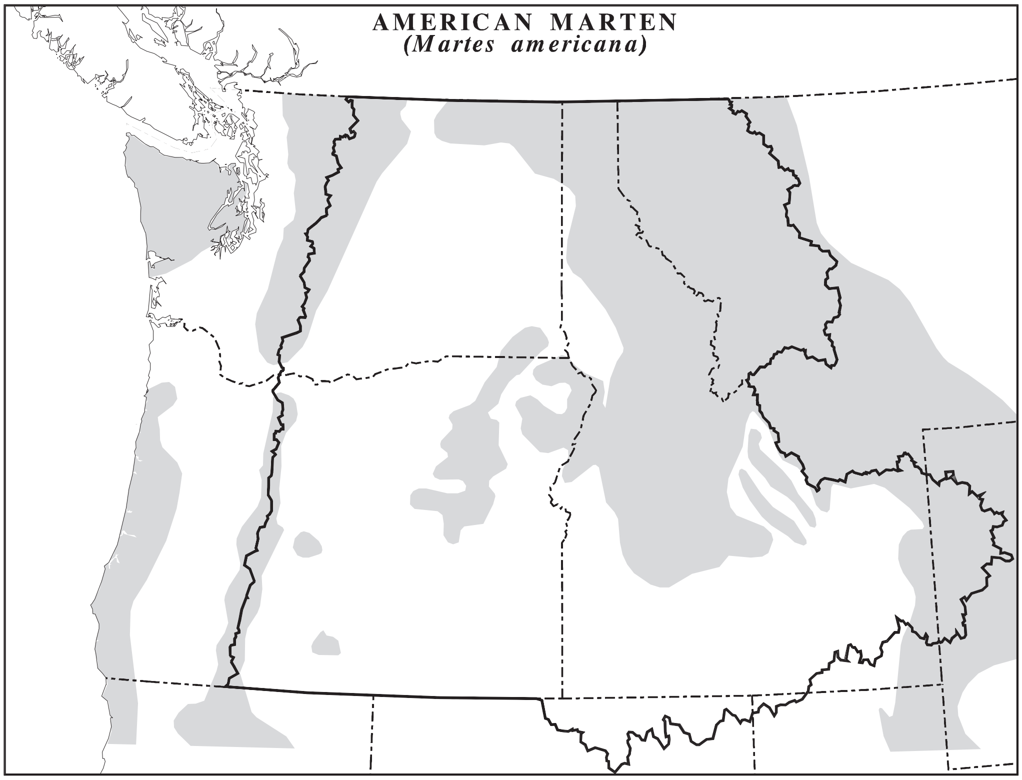

FISHER
(Martes pennanti)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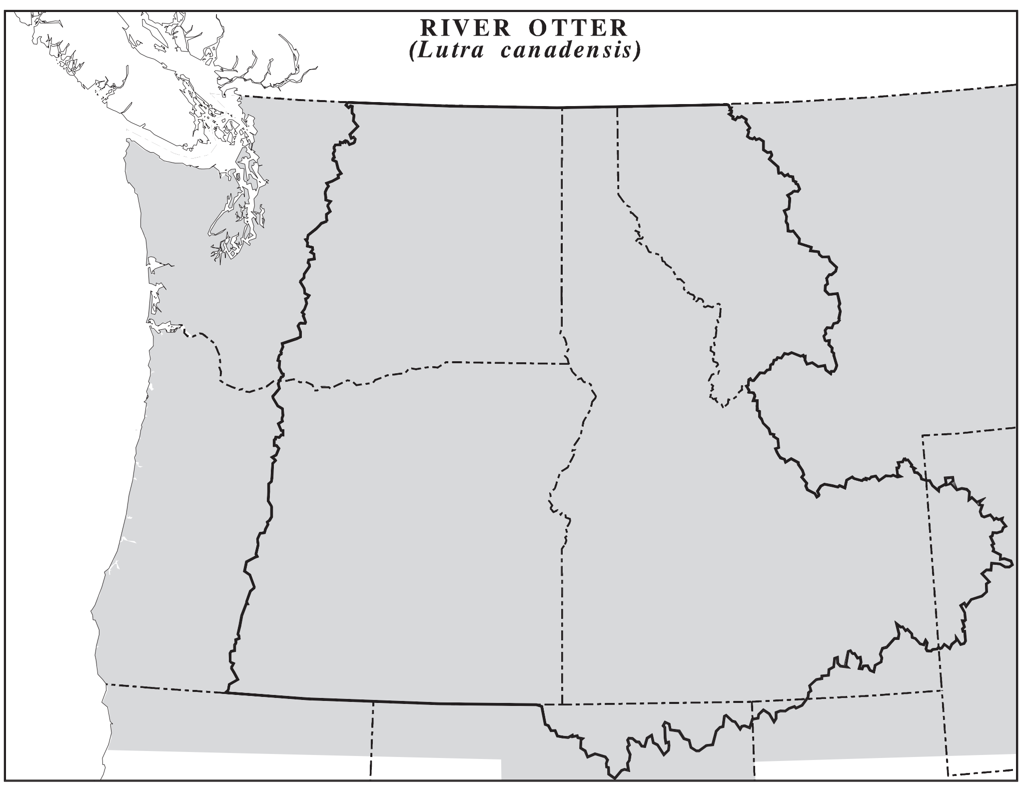
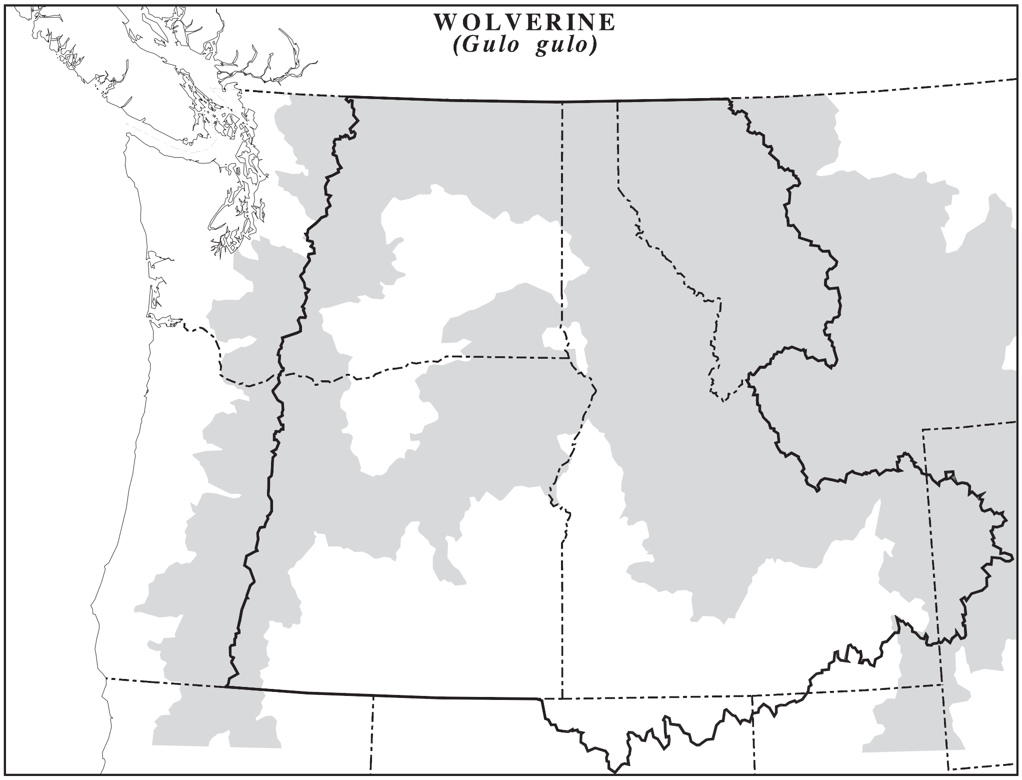
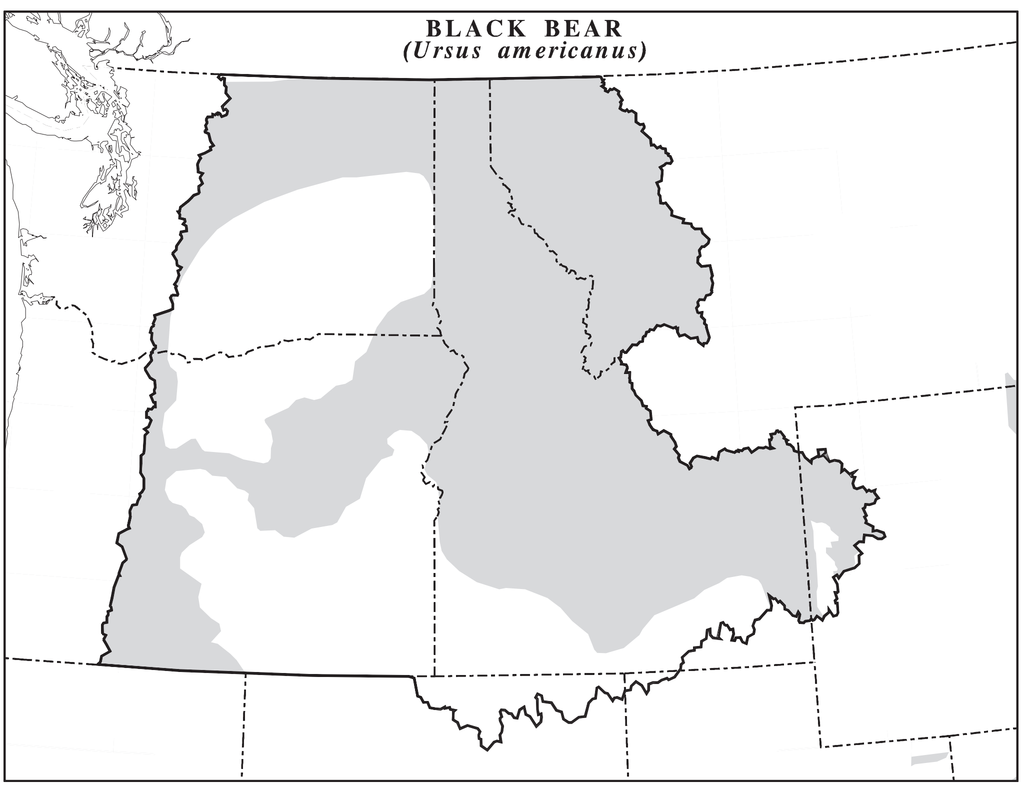
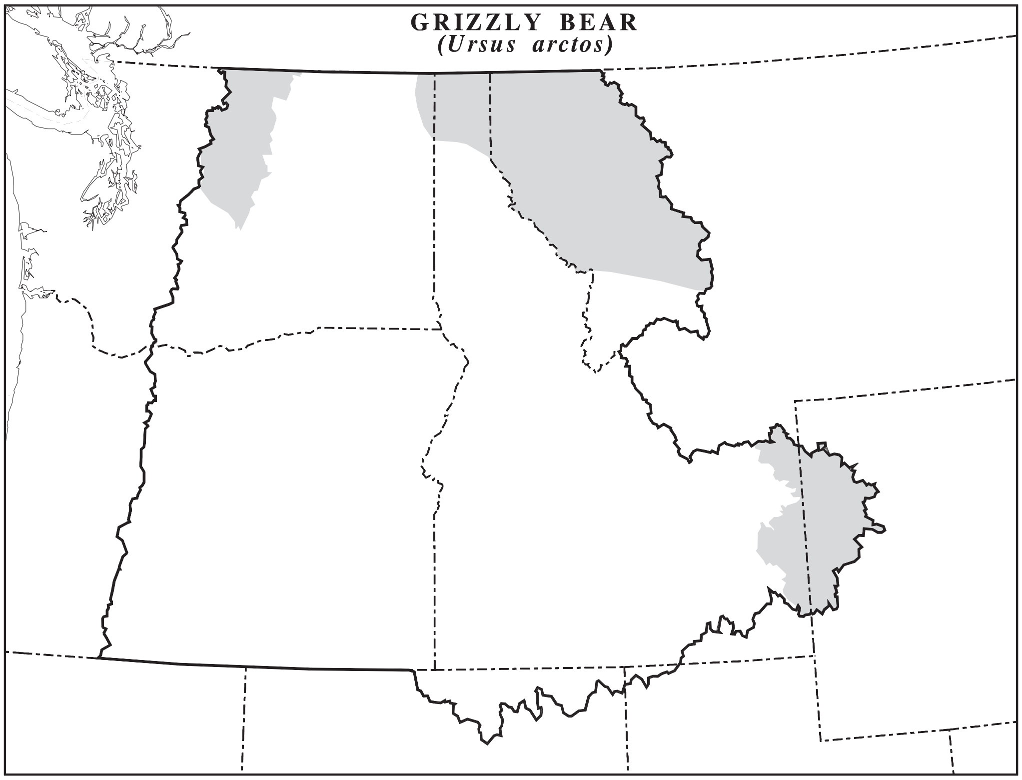
(Martes americana)


RIVER OTTER
(Lutra canadensis)


WOLVERINE
(Gulo gulo)


BLACK BEAR
(Ursus americanus)


GRIZZLY BEAR
(Ursus arctos)

Appendix B

Summary of Biology, Ecology, and Status by Species

Species	Adult size and kilograms	Reproductive potential	Home range and km^2	Primary habitat	Primary prey	Status in basin
Coyote	Medium 10-16	High	Small 4-12	Various, successional mix	Diverse, omnivore	Unprotected, harvested
Gray wolf	Large 20-80	Moderate to high	Very large 100-1000+	Remote areas	Ungulates	Protected
Bobcat	Medium 5-25	Moderate	Small 2-40	Various, successional mix	Small to medium mammals	Harvested
Lynx	Medium 7-20	Moderate	Small 16-20	Successional mix	Small to medium mammals	Protected or limited harvest
Mountain lion	Large 35-80	Moderate	Very large 100-1000	Successional mix	Ungulates	Harvested
Fisher	Small 2-5	Moderate	Moderate 20-80	Mature forest	Small to medium mammals	Protected or limited harvest
Marten	Small 0.5-1	Moderate	Very small 1-5	Mature forest	Small mammals	Harvested
River otter	Medium 5-14	Low to moderate	Moderate 10-80	Riparian habitats	Fish, diverse	Harvested except in Idaho
Wolverine	Medium 15-30	Low to moderate	Large 100+	Mature forest	All-sized mammals	Protected or limited harvest
Black bear	Very large 40-140	Low	Moderate 10-100	Successional mix	Diverse, omnivore	Harvested
Grizzly bear	Very large 80-250	Low	Very large 1500+	Successional mix	Diverse, omnivore	Protected

Appendix C

Summary of Population Status and Harvest by Species and Area

Species and area	Classification	Status	Harvest no. (period)	Harvest trend (period)
Coyote:				
Eastern Oregon	Predatory mammal	Unprotected	4500 (1994-95)	Stable or increasing (1985-95)
Eastern Washington	Predatory mammal	Unprotected	1415 (1994-95)	Stable or increasing (1983-94)
Idaho	Predatory mammal	Unprotected	1825 (1993-94)	Stable or increasing (1984-94)
Northwest Montana	Predatory mammal	Unprotected	1198 (1993-94)	Stable (1984-94)
Wolf:				
Eastern Oregon	Game mammal	Protected	No harvest	—
Eastern Washington	Game mammal	Protected	No harvest	—
Idaho	Game mammal	Protected	No harvest	—
Northwest Montana	Game mammal	Protected	No harvest	Occasional incidental take
Bobcat:				
Eastern Oregon	Furbearer	Regulated harvest	1017 (1994-95)	Stable (1985-95)
Eastern Washington	Furbearer	Regulated harvest	251 (1993-94)	Stable or increasing (1983-94)
Idaho	Furbearer	Regulated harvest	312 (1993-94)	Decreasing (1984-94)
Northwest Montana	Furbearer	Regulated harvest	265 (1994-95)	Stable (1991-95)
Lynx:				
Eastern Oregon	Furbearer	Protected (extirpated)	No harvest	—
Eastern Washington	Furbearer	Protected	No harvest (since 1991)	Decreasing (1970-91)
Idaho	Furbearer	Regulated harvest (quota)	1 (1993-94)	Decreasing (1984-94)
Northwest Montana	Furbearer	Regulated harvest (quota)	4 (1994-95)	Decreasing (1984-95)
Mountain lion:				
Eastern Oregon	Game mammal	Regulated harvest	93 (1992)	Increasing (1970-92)
Eastern Washington	Game mammal	Regulated harvest	148 (1994-95)	Increasing (1989-95)
Idaho	Game mammal	Regulated harvest	448 (1993-94)	Stable or increasing (1988-94)
Northwest Montana	Game mammal	Regulated harvest	258 (1993-94)	Increasing (1984-94)
Fisher:				
Eastern Oregon	Furbearer	Protected	No harvest	—
Eastern Washington	Furbearer	Protected	No harvest	—
Idaho	Furbearer	Protected	No harvest	Occasional incidental take
Northwest Montana	Furbearer	Regulated harvest (quota)	8 (1994-95)	Stable (1984-95)
Marten:				
Eastern Oregon	Furbearer	Regulated harvest	10 (1994-95)	Decreasing (1985-95)
Eastern Washington	Furbearer	Regulated harvest	40 (1993-94)	Decreasing (1983-94)
Idaho	Furbearer	Regulated harvest	364 (1993-94)	Decreasing (1984-94)
Northwest Montana	Furbearer	Regulated harvest	631 (1993-94)	Decreasing (1984-94)
River otter:				
Eastern Oregon	Furbearer	Regulated harvest	84 (1994-95)	Stable (1985-95)
Eastern Washington	Furbearer	Regulated harvest	35 (1993-94)	Stable or increasing (1983-94)
Idaho	Furbearer	Protected	No harvest	Occasional incidental take
Northwest Montana	Furbearer	Regulated harvest	26 (1994-95)	Stable (1984-94)

Species and area	Classification	Status	Harvest no. (period)	Harvest trend (period)
Wolverine:				
Eastern Oregon	Furbearer	Protected	No harvest	—
Eastern Washington	Furbearer	Protected	No harvest	—
Idaho	Furbearer	Protected	No harvest	Occasional incidental take
Northwest Montana	Furbearer	Regulated harvest	3 (1994-95)	Stable (1984-95)
Black bear:				
Eastern Oregon	Game mammal	Regulated harvest	About 270 (1992)	Stable (1975-92)
Eastern Washington	Game mammal	Regulated harvest	781 (1992-93)	Stable (1984-93)
Idaho	Game mammal	Regulated harvest	1231 (1993-94)	Stable or increasing (1983-94)
Northwest Montana	Game mammal	Regulated harvest	About 750 (1993)	Stable (1986-93)
Grizzly bear:				
Eastern Oregon	Game mammal	Protected (extirpated)	No harvest	—
Eastern Washington	Game mammal	Protected	No harvest	—
Idaho	Game mammal	Protected	No harvest	—
Northwest Montana	Game mammal	Protected	No harvest	Occasional incidental take

Appendix D

Summary of Informational Needs and Management Issues by Species

	Species										
Needs or issues	Coyote	Gray wolf	Bobcat	Lynx	Mountain lion	Fisher	Marten	River otter	Wolverine	Black bear	Grizzly bear
Maintain late successional forest						X	X				
Maintain dispersal corridors					X	X	X	X			X
Maintain riparian habitat						X		X			
Large undisturbed areas		X			X				X		X
Maintain mix of seral stages			X	X						X	
Maintain prey population		X			X				X		
Reduce mortality from humans		X		X	X	X	X	X	X		
Reduce conflicts with humans	X	X			X					X	X
Succeed with reintroductions		X									X

Witmer, Gary W.; Martin, Sandra K.; Sayler, Rodney D. 1998. Forest carnivore conservation and management in the interior Columbia basin: issues and environmental correlates. Gen. Tech. Rep. PNW-GTR-420. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 51 p. (Quigley, Thomas M., ed.; Interior Columbia Basin Ecosystem Management Project: scientific assessment).

Forest carnivores in the Pacific Northwest include 11 medium to large-sized mammalian species of canids, felids, mustelids, and ursids. These carnivores have widely differing status in the region, with some harvested in regulated furbearer seasons, some taken for depredations, and some protected because of rarity. Most large carnivores have declined in numbers or range from human encroachment, loss or modification of forest habitat, accidental deaths (e.g., mortality from vehicles), illegal kills, and our inability to adequately monitor and protect populations. Efforts to reverse these trends include new approaches to reduce conflicts with humans, research to better define habitat needs, formation of expert carnivore working groups, and use of Geographic Information System models to predict specific impacts of habitat modifications. Long-term preservation of large carnivores in the region is problematic unless we reduce forest fragmentation and conflicts with humans and improve our ability to quantitatively integrate population dynamics with landscape level habitat requirements.

Keywords: Coyote, gray wolf, bobcat, lynx, mountain lion, fisher, marten, river otter, wolverine, grizzly bear, black bear, conservation, management, carnivores, late successional forest, wilderness, roads, disturbance, fragmentation, conservation biology, geographic information systems, forest management, animal damage.

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