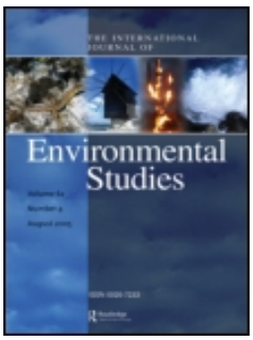

International Journal of Environmental Studies

ISSN: 0020-7233 (Print) 1029-0400 (Online) Journal homepage: http://www.tandfonline.com/loi/genv20

Conservation and management of large carnivores in North America

Sterling D. Miller , Bruce N. McLellan & Andrew E. Derocher

To cite this article: Sterling D. Miller , Bruce N. McLellan & Andrew E. Derocher (2013) Conservation and management of large carnivores in North America, International Journal of Environmental Studies, 70:3, 383-398, DOI: 10.1080/00207233.2013.801628

To link to this article: http://dx.doi.org/10.1080/00207233.2013.801628

Published online: 07 Jun 2013.

International Journal of Environmental Studies, 2013
Vol. 70, No. 3, 383–398, http://dx.doi.org/10.1080/00207233.2013.801628

Routledge
Taylor & Francis Group

Conservation and management of large carnivores in North America

STERLING D. MILLER†*, BRUCE N. MCLELLAN‡ AND ANDREW E. DEROCHER‡

†National Wildlife Federation, 240 North Higgins, Suite #2, Missoula, MT 59802, USA
‡British Columbia Ministry of Forests, PO Box 1732, D'Arcy, BC V0N 1L0, Canada
§Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9, Canada

Between the eighteenth and twentieth centuries in North America, large carnivores were significantly reduced in numbers and distribution. Wildlife management priorities changed during the last century to emphasize recovery and conservation with benefits to all species. Populations of large carnivores are likely to persist and expand into new areas within their original range where habitats are both socially and biologically suitable. Polar bears (*Ursus maritimus*) are an exception to this pattern as major contractions in numbers and distribution caused by global warming are now unavoidable. The extinction of polar bears during the twenty-first century is possible without great reductions in atmospheric greenhouse gases. Conservation and management of large carnivores is complicated because they require large landscapes, they may compete with hunters for ungulate prey, they can adversely impact economic activities such as livestock operations, and they sometimes, although rarely, attack and kill people.

Keywords: Black bears; Brown bears; Cougars; North America; Polar bears; Wolves

It is ordered, that there should be 10 shillings a piece allowed for such wolves as are killed. Wolf legislation in the Colony of Massachusetts Bay, 1637 [1:1].

We reached the old wolf in time to watch a fierce green fire dying in her eyes. I realized then, and have known ever since, that there was something new to me in those eyes – something known only to her and to the mountain. I was young then, and full of trigger-itch; I thought that because fewer wolves meant more deer, that no wolves would mean hunters' paradise. But after seeing the green fire die, I sensed that neither the wolf nor the mountain agreed with such a view. [2:essay on "Thinking like a Mountain"].

Background and scope

During the settlement of North America by European immigrants, large carnivores were targeted as undesirable species that impeded settlement and represented threats to the settlers' economic interests and safety; many species declined or were locally extirpated as a consequence [3]. By the early twentieth century, the distributions and abundance of all

*Corresponding author: Present address: Dunrovin Research, PO Box 822, Lolo, MT 59847, USA. Email: sterlingmil@gmail.com

terrestrial large carnivores, other than polar bears, were significantly reduced in large portions of North America. Declines resulted both from excessive killing and from conversion of habitat for human use. Polar bears (*Ursus maritimus*) declined in abundance (from commercial harvest), but not in distribution [4]. The nineteenth- and early twentieth-century reductions of large carnivores were most extreme in the contiguous USA and eastern/central Canada. Declines were less extreme or did not occur in more mountainous and lightly populated portions of western and northern Canada and Alaska. Today, these abridged distributions persist, but earlier declines in distribution and abundance have slowed or been reversed in at least some areas for all large carnivore species.

During the twentieth century, attitudes toward large carnivores and the value of natural areas and habitat began to change. In the USA, this change was spurred by the interest in wild area and wildlife preservation by Teddy Roosevelt (US President 1901–1909), the rise of wildlife management as a profession, and the publication of *Game Management* by Aldo Leopold (1933) and his essays, *A Sand County Almanac* (1949) [2]. John Muir (1838–1914) and Gifford Pinchot (1865–1946) also contributed greatly to the establishment of the National Parks and National Forests that became key refugia for many species of wildlife decimated by overhunting. Muir formed the Sierra Club in 1892. Hunting organizations and avid hunters like Roosevelt played an important initial role in the restoration of wildlife populations and many hunting organizations continue to play strong roles in conservation efforts for large carnivores. Many other wildlife advocacy organizations originated in the latter half of the twentieth century [3]. The National Wildlife Federation, for example, was organized at the first North American Wildlife Conference in 1936.

Some of these advocacy organizations focused especially on restoration of large carnivores that had been extirpated from large portions of the lower 48 states and many parts of southern Canada by the mid-twentieth century. Correlated with the decline in the number and range of large carnivores and the rapid urbanization of North America, attitudes and actions towards large carnivores shifted from persecution towards protection. This shift was more marked among citizens living far from large carnivores, than among those living near these species. A compilation of studies indicated that positive attitudes towards wolves (*Canis lupus*), for example, were slightly higher in the wolf-free eastern USA (64%) compared to the western USA (57%) where wolves were becoming re-established [5]. In Alaska and Canada, where wolves remain abundant; the same study found that positive attitudes were even less common (45%).

In this paper, we discuss the conservation and management challenges facing the five largest species of carnivores in North America (excluding Mexico): the brown bear, the American black bear (*U. americanus* [hereafter black bear]), the polar bear, the cougar (*Felis concolor*) and wolves. In North America, the brown bear is commonly called the 'grizzly' bear in non-coastal areas and the 'brown' bear in salmon-rich coastal areas; there is no taxonomic difference associated with these names. We do not consider the jaguar (*Panthera onca*) because the USA is at the northern limit of their range.

Large carnivore life history traits

A defining characteristic of large carnivores is that they kill and eat other animals. The amount of meat in the diet varies among species, as well as among individuals and among populations within some species; this variability in meat consumption is most marked for black and brown bears. The polar bear is the most specialized large carnivore in North

America and is an obligate predator subsisting largely on seals [4,6–8]. The most common prey are ringed seals (*Pusa hispida*) and bearded seals (*Erignathus barbatus*), with other marine mammals including walrus (*Odobenus rosmarus*) and whales (e.g. beluga whales *Delphinapterus leucas*) taken occasionally [9]. Brown and black bears occupy a wide range of habitats and eat a diversity of foods, including plants (grass, herbs, roots and berries), insects, fish and meat from animals they kill (primarily neonatal ungulates and fossorial mammals) or scavenge [10,11]. Because of their highly diverse and omnivorous foraging behaviour, these bears can come into conflict with humans when they are attracted to refuse or other human foods. The likelihood of these kinds of conflicts is higher for brown and black bears than other large carnivores because they hibernate during winter and therefore have only part of the year to accumulate the nutritional reserves necessary to sustain them during denning periods. Cougars are ambush predators of ungulates, including deer (*Odocoileus* spp.), caribou (*Rangifer tarandus*), elk (*Cervus elaphus*), bighorn sheep (*Ovis canadensis*) and sometimes moose *(Alces alces)*; they also prey on smaller animals like beaver (*Castor canadensis*) and porcupines (*Erethizon dorsatum*) [12,13]. Wolves also are efficient predators. They primarily kill ungulates including moose, caribou, elk, deer, bison (*Bison bison*), bighorn sheep and thinhorn sheep (*O. dalli*); they also kill small mammals and birds [14]. Although wolves and cougar will kill healthy adult ungulates, they select easier-to-kill vulnerable individuals when possible [15]. Wolves are pack animals that cooperate in killing prey and rearing young [14–16]. Except for wolves, the large carnivores discussed here are typically solitary, except for females rearing young and, for bears, aggregations at concentrated sources of food.

Black and brown bears and pregnant polar bears hibernate during winter in dens. The other large carnivores and non-pregnant polar bears are active throughout the year.

Management challenges for large carnivores

Large carnivores create challenges for managers seldom posed by other wildlife species. For example, although extremely uncommon in North America, all of the carnivore species discussed here have occasionally attacked and killed human beings [17–20]. In addition, brown bears and wolves frequently, and black bears and cougars occasionally, kill domestic livestock (sheep, cattle and poultry) and pets (dogs and cats) and losses can be both financially and emotionally significant [21]. Brown and black bears, wolves and cougars can compete with man for wild ungulate prey and there are pressures to reduce such predation by controlling carnivore abundance (e.g. [22]). In portions of their ranges, those carnivores that depend on abundant primary prey (often moose or deer) are threats to small and endangered populations of secondary prey species including woodland caribou (*R. t. caribou*), desert bighorn sheep (*O. c. nelsoni*) and muskoxen (*Ovibos moschatus*).

Status and distribution

All species of large carnivores in North American considered here are currently listed as being extirpated or at risk in large portions of their historic distribution, but are abundant and not threatened in other areas [23]. Polar bears are still abundant throughout their historical range, but because of climate change and continued shrinkage of the polar ice cap, which is their habitat, this status is not expected to persist [4,24–28]. In Canada's Hudson

Bay, polar bear populations are declining because of longer, ice-free, summer periods caused by global warming [4,29]. The polar bear was listed in 2008 under the US Endangered Species Act (ESA) as a *threatened* species throughout their range [30]. The polar bear was listed under the ESA criteria 'Present or threatened destruction, modification, or curtailment of [its] habitat or range' [30]. In Canada, polar bears were listed in 2011 under the federal Species at Risk Act (SARA) as a species of special concern. *Special concern* is a lower level of risk than *threatened.* The Canadian provinces of Ontario, Manitoba, Newfoundland and Labrador have listed polar bears as threatened.

In the USA, brown bears once occurred throughout much of the Great Plains and Western States. They now occur primarily in, and near, Yellowstone National Park and in, near, and south of Glacier National Park along the Continental Divide. There are also small populations in north western Montana (Cabinet-Yaak Mountains) and northern Idaho (Selkirk Mountains). Occasional individuals are seen in north western Washington (North Cascades National Park) adjacent to Canada. Brown bear distribution in Canada remains relatively intact except for the prairie portions of Alberta, Saskatchewan and Manitoba. Brown bears currently inhabit essentially all of their original range in Alaska, perhaps 60% in Canada (their early distribution east of Hudson Bay is uncertain), and about 2% in the US south of Canada [31]. In both the USA and Canada, populations no longer occur in the prairies, and populations are at risk in some southern parts of British Columbia and forested portions of Alberta [11]. In the lower 48 states, brown bears were listed as 'threatened' under the ESA in 1975 and then delisted in, and around, Yellowstone Park in 2009 because recovery criteria identified in the 1993 recovery plan had been achieved. These recovery criteria included abundance, distribution and maximum mortality levels. Subsequently, litigation from some wildlife advocacy groups resulted in the re-listing of Yellowstone-area brown bears in 2009. This decision was appealed and part of it was upheld by the appeals court in December 2011 returning grizzly bears to the list of threatened species under the ESA. The US Fish and Wildlife Service is addressing the issue that the appeals court found lacking (possible declines in a food source) and is expected to propose delisting again in 2014. In 2013, a process was initiated which is designed to lead to delisting grizzly bears in the Northern Continental Divide Ecosystem in Montana. This initial step was the release for public comment of a draft Conservation Strategy describing how lands and populations in this area would be managed if grizzly bears are delisted there.

Black bears once inhabited all forested habitats in North America and were absent only in prairie, extreme desert and northern tundra habitats. Current distribution is largely unchanged in Canada and Alaska and in mountainous areas south of Canada (Rocky, Adirondack and Pacific coastal mountains). Black bears remain abundant in the coniferous forests of the mid-west and deciduous forests of the north eastern USA and occur in isolated populations elsewhere within their original US distribution as far south as Florida and Mexico. Populations have been re-established by reintroduction into Arkansas (1960s and 2000–2007) and Tennessee (mid 1990s), by augmentation in Louisana (1960s), and by natural re-colonization by dispersal into Texas [32,33]. Currently, the black bear occupies approximately 62% of its historic range, with almost all range loss being south of Canada; populations appear secure in most areas where adequate forested habitat persists [10]. Subspecies of black bear in Florida and Louisiana are listed as threatened under the ESA, but are secure elsewhere in the USA and Canada. There are hunting seasons in all states and provinces with adequate populations [34]. The white-phased Kermode black bear is protected in British Columbia.

Wolves once inhabited essentially all of the USA except the south eastern states. By the 1930s, wolves were extirpated in almost all of the USA (except Alaska). Wolves currently occur as a contiguous population across Canada and Alaska and in a few states in the Northern Rocky Mountains (Idaho, Montana and Wyoming) and adjacent to the Great Lakes (Minnesota, Wisconsin and Michigan). Wolves dispersing south from Canada naturally re-colonized a small area near Glacier National Park and the first den there was documented in 1986. This northern US population grew slowly, sparking support for a reintroduction programme in the USA. Wolves from Canada were translocated into Yellowstone Park and central Idaho in 1995 and populations grew rapidly. Some of the wolves reintroduced into the Rocky Mountain states of Idaho, Montana and Wyoming are now dispersing into Washington, Oregon, Utah and Colorado [35]. Wolves were never completely extirpated in the Great Lakes area and a few hundred remained in north eastern Minnesota and on Isle Royale in Lake Superior when the species was listed under the ESA in 1974. Currently, there are more than 4000 wolves in the Great Lakes area (Minnesota, Michigan and Wisconsin) [36].

A wolf subspecies (the 'Mexican wolf') was extirpated in the USA, but was reintroduced in 1998 and a small population of about 50 wolves persists in Arizona and New Mexico [15,16]. A subspecies or possible species (*Canis rufus* or 'red wolf') has a reintroduced population of about 100 individuals in North Carolina, but this form has uncertain taxonomic status; it is possibly a unique species, an eastern grey wolf, or a coyote-wolf hybrid [37,38]. The taxonomy is also uncertain for what has been called the 'eastern grey wolf' (potentially *C. lycaon*, the same taxon as red wolves, or a hybrid with coyotes). Whatever it is, the form is considered extinct in the USA although possibly still surviving in Canada, including Algonquin Park in Ontario [39]. Currently, wolves persist across their historic range in Alaska and across about 80% of their historic range in Canada.

In 1974, wolves were listed under the ESA as 'endangered' in the US Rocky Mountains and as 'threatened' in the Great Lakes area. In the USA, the Northern Rocky Mountain wolves met ESA recovery goals in 2002 and continued to expand in numbers and distribution. Attempts by the US Fish and Wildlife Service (USFWS) to delist wolves from the ESA in the Great Lakes and Northern Rocky Mountain areas have been continuing since 2007 [40–42], but delisting efforts were successfully opposed in court by some wildlife advocacy groups. Frustration regarding recurrent litigation causing continued listing of a growing population of wolves in the Northern Rocky Mountains led to congressional intervention in April 2011. This intervention delisted wolves in Montana, Idaho and parts of Washington, Oregon and Utah in a way that mirrored the USFWS's delisting proposal [43]. Wolves were not delisted in Wyoming because that state was thought to have inadequate regulatory mechanisms including, in much of the state, classification of the species as a 'predator' allowing them to be taken without the restrictions afforded to 'game animals'. Negotiations are currently underway between the State of Wyoming and the USFWS to delist wolves in Wyoming as well. Some wolf advocacy groups challenged in court the intervention by Congress that led to the delisting of wolves in Montana and Idaho but this challenge was not successful. In late 2011, wolves were delisted in the Great Lakes area (Minnesota, Wisconsin and northern Michigan) [36].

When species are listed under the ESA, the US federal government assumes primary management authority for the species. This management authority was formerly held by individual states. Land use practices that may jeopardize the recovery of the species when listed or which may result in excessive 'take' (mortalities) are constrained on both public and private lands. When species are delisted from the ESA, management authority is

returned to the individual states. For delisted wolves, the states have moved quickly to institute hunting seasons in an effort to control wolf numbers, distribution and wolf depredations on wild ungulates and domestic livestock.

Cougars have been largely extirpated in the US east of the Rocky Mountain states, but retain most of their original distribution in western Canada (mostly British Columbia and western Alberta). No population is thought to exist in Alaska. Cougars occupy about one third of their historical range across the USA [12]; they are extirpated in eastern and central USA, although recent sightings (have been reported in the US Midwest and east (Minnesota, Wisconsin, Iowa, Indiana and Connecticut). Many of these eastern sightings were determined to be of the same individual that came from South Dakota (a largely prairie state) where there has been a hunted population since 2005. In 2011, the 'eastern' cougar (a subspecies of uncertain validity) was officially declared to have been extinct since the 1930s, but this taxon may not be a legitimate subspecies separate from western and northern cougars [44]. There are fewer than 100 surviving Florida panthers and this cougar subspecies is listed as endangered by both the ESA and Florida. In Canada, cougars have been depleted from Saskatchewan to New Brunswick, and the Committee on the Status of Endangered Species in Canada lists the eastern cougar as 'data deficient'. In the western USA and western Canada, cougars are generally abundant and managed as game animals. Cougar hunting has been illegal in California since 1990, however, because of a ballot measure approved by California voters.

Hunting large carnivores

In North America, large carnivores are hunted primarily as trophy species for their hides and skulls, although bears and cougars are used as food by some hunters. Bears are regularly used for food by First Nations people (Native Americans). Hunting techniques for cougars commonly involve the use of dogs to tree cougars. In some areas this technique is also used for black bears. In many jurisdictions in both Canada and the USA, baiting of black bears is a common and legal hunting technique although it remains controversial in other areas [34]. It is illegal to use bait or dogs to hunt brown bears throughout North America except in one portion of Alaska. In some Canadian provinces, and in Alaska and parts of Maine, black bears are considered furbearers and trapping is legal. Bounties are not currently paid by states or provinces to encourage the killing of any large carnivores in North America, although, in Ontario, bounties were paid for black bears as recently as 1961 [45] and bounties were also paid for cougars in many states into the early 1960s [46,47]. Bounties were paid on wolves in the USA into the 1930s.

Where populations are not threatened, North American large carnivores are managed by state or provincial agencies as big game, often with significant, but sustainable, harvest as the management goal. Mirroring an increasing bear population in the USA excluding Alaska, the three-year average black bear harvest (1999–2001) increased by 65% to 21,080 animals compared to 1987–1989 [34]. In Canada, the estimated harvest increased by 2% to more than 20,000 animals during the same period [34]. Total annual average black bear harvest in the USA is about 27,630 bears with Minnesota having the highest harvest (2873) [compiled from 46]. In Canada, average annual black bear sport harvest is 19,105 (not including trapped bears) and the largest number is taken in Ontario (6274) [compiled from 46]. There was an annual average take of 1043 cougars in 11 western US states during 1971–1980 [47]. During 1990–2007, 12 western US states reported average

annual harvests of 2462 cougars and a stable trend while the Provinces of British Columbia and Alberta reported average annual harvests of 315 with an increasing trend [46]. Because they are listed under the ESA, there is no legal hunting of brown bears south of Canada, but, currently, the states of Montana, Wyoming and Idaho have management plans that will allow limited hunting of brown bears if the species is delisted. About 1600 brown bears are taken annually by sport hunters in Alaska and Canada and an additional 204 animals in control, and other non-hunting, kills [11]. Brown bear harvests have increased dramatically in most of Alaska in recent decades in response to intentional efforts to use sport hunting as a tool to reduce bear abundance and bear predation on moose and caribou [46,48]. In Alaska and Canada, almost 700 polar bears are killed each year in subsistence, quota hunts and kills of problem individuals [4].

In 2009, the first year of hunting was allowed following wolf delisting in the US Northern Rocky Mountains; 207 wolves were taken by hunters in Idaho and Montana [35]. The following year, a legal challenge to delisting stopped the hunt in these two states. Following delisting by congressional action, a take of up to 220 wolves was allowed in Montana during the 2011 season. Only 166 were taken, however, and the wolf population increased by an estimated 15%. This population increase and the difficulty in achieving desired levels of take will likely lead to adoption of regulations designed to increase harvests in Montana. There is no quota for the approximately 1000 wolves in Idaho during 2011. Idaho officials aim to reduce wolf numbers but maintain more than 150 animals and at least 15 breeding pairs. Hunting of delisted wolves in Minnesota and Wisconsin in the Great Lakes area began in fall 2012. Hunters killed 413 wolves out of a quota of 413 in Minnesota and 117 wolves from a target of 116 wolves in Wisconsin. Hunting is expected to begin in Michigan in fall 2013. Resumption of hunting in the Great Lakes continues to be litigated by groups opposed to hunting wolves. Annually, about 1447 wolves are reported taken in Alaska by hunters and trappers (mean for 1990–2006) [46,49]. It is likely that most wolves killed by hunters in North America are killed incidental to ungulate hunting [50]. An annual average of about 3172 wolves was reportedly taken by hunters and trappers in Canada during 1980–2006 [46]. In Alberta, 10,140 wolves were reported trapped on registered trap lines during 1985–2006, with a peak of 803 animals in 2006 [51,52]. Wolves are prolific compared to other large carnivores in North America and can sustain relatively high harvest rates [50–53].

In addition to legal hunting, large carnivores are sometimes killed by agency personnel to eliminate individuals that cause damage to property (i.e. livestock) or threaten human safety. These nuisance-mortalities represented 3% (black bear) and 5% (brown bear) in Alaska of the total known mortalities; nuisance-mortalities were higher in more populated portions of Alaska where they accounted for 6% (black bears) and 22% (brown bears) of mortalities during the 1990s [54]. In the US south of Canada prior to the advent of hunting of delisted wolves, all man-caused mortalities of wolves resulted from control actions or illegal kills. During 2000–2004, there was an average of 46 nuisance wolf kills south of Canada (range = 19–86/year) compared to an average of 192 (range = 103–270/year) during 2005–2009 [40,41]. The increasing number of control kills south of Canada reflects the increasing abundance of wolves and their expansion into areas where their presence is problematic [50]. Wolf control in parts of Canada has been focused on animals that killed livestock and, in some areas, to aid in the recovery of endangered woodland caribou populations.

In North America, the implications of hunting large carnivores are variable and insufficiently studied. It is clear that human exploitation (hunting, trapping and poisoning) once

eliminated large carnivores from large portions of their former ranges. Re-colonization of former areas is unlikely where human populations are dense, habitat modification is extensive or large carnivores are viewed as threatening to human safety or economic interests. Instead, large carnivores are likely to retain a significant presence primarily in remote and lightly populated landscapes. Since cessation of cougar hunting in California by public referendum, cougars have become increasingly abundant and occasionally problematic in some suburban areas adjacent to wildlands [46].

In addition to hunting for trophies or food, large carnivores are commonly managed by agencies to achieve more general objectives including: (1) preventing populations from increasing above target levels; (2) reducing competition for game species such as wild ungulates; (3) reducing conflicts with property, such as depredation on livestock; (4) providing recreational or subsistence hunting opportunities; (5) relieving excessive predation rates on threatened species; and (6) reducing threats to human safety [55]. In addition, an objective for polar bear management in both Alaska and Canada is to permit native communities to continue the economically and culturally important harvest of this species. The polar bear harvest is limited to native people in North America. In Canada, natives may sell rights to harvest polar bears to non-native sport hunters [56] and there is resistance from native hunters to reduction of harvest quotas. In Alaska, natives may not sell rights to harvest polar bears but may kill polar bears for food and may sell handicraft items made from polar bears.

Some hunters and hunting organizations have been strongly supportive of recovery efforts for large carnivores while others have opposed these efforts; largely because of concerns that carnivore recovery will lead to reduced abundance of wild ungulates which hunters prefer to hunt. Alaska is the most aggressive jurisdiction in efforts to reduce large carnivores to increase the number of ungulates available to hunters. Such sentiments are common even in areas without scientific studies supporting the efficacy of large carnivore reductions to increase ungulates [48,57]. In other areas such evidence exists [58].

Survey results contrast differences in attitude between hunters and the general public regarding the acceptability of reducing large carnivores to increase the number of ungulates. A survey of Alaskans showed more support among resident hunters (65%) than among voters (48%) for killing wolves to increase numbers of wild ungulates [59]. In Wisconsin, a survey of all hunters, including carnivore hunters, showed that both groups supported a significantly lower wolf population than did non-hunters [60]. A majority of hunters in both the Great Lakes and the US Northern Rocky Mountains did not support stewardship of wolves [60]. Stewardship was defined as a complex set of attitudes that included, but was not limited to, championship of conservation, acceptance of carnivore policy toward wolves as game animals and adherence to hunting regulations [60]. But, hunters commonly supported restoration efforts and sustainable harvests of large carnivores that have trophy value, such as for the restoration of black bears in Texas [61]. Wyoming hunters (44%), however, were more likely than non-hunters (29%) to say that there are no benefits to wolf reintroduction [62]. Similarly, 24% of the hunters supported, and 67% opposed, wolf reintroduction to Adirondack Park in New York State in 1997 [62].

The relationships between ungulate abundance and presence or abundance of large carnivores are varied and complex [46]. Predator control, especially of wolves, has been shown to be occasionally efficacious at maintaining higher densities of ungulates than would exist otherwise [22,58], but not in many others [63,65]. Even where it is effective, wolf control in portions of the Yukon in Canada was concluded not to be a cost-effective way to increase moose and caribou populations [64]. Efforts to reduce brown bears to

increase huntable populations of ungulates have been occurring for decades in Alaska without demonstrated efficacy [48].

Management responsibility and objectives

In the USA, most wildlife species are managed primarily by the states, but the situation is more complicated for some large carnivores. For instance, polar bears are classified as marine mammals and have been managed by the US federal government since the 1972 Marine Mammal Protection Act. The US federal government has primary responsibility for management of those species in areas where they are listed under the ESA including brown bears, wolves and the southernmost populations of black bears and cougars. Where these species are listed, state and tribal agencies still play a significant management role and collaborate with federal authorities. Where large carnivores are not listed, they are managed by state and tribal wildlife management agencies and hunting can be permitted. When species are delisted (removed from ESA protections), primary management authority reverts to state and tribal wildlife agencies and federal agencies become cooperators.

In Canada, carnivores are managed by provincial or territorial governments except in national parks, where the federal government's Parks Canada has management responsibility. Black bears are hunted in all 12 provinces and territories where they occur (they are not found on Prince Edward Island), and brown bears are hunted in four of the five jurisdictions where they occur. Brown bear hunting was suspended in Alberta in 2006 because population estimation suggested fewer bears than previously thought. Cougar are only hunted in British Columbia and Alberta, whereas wolves are hunted and trapped in all 10 jurisdictions where they are found. Polar bears are hunted by, or under, the authority of native peoples throughout their range in Canada, except Manitoba where no hunting is allowed.

Recovery objectives for species listed under the ESA include the identification of targets that will be used to determine when objectives have been met. These targets frequently include abundance goals. For wolves in the Great Lakes area, for example, the recovery plan had an objective of at least 1250 wolves in Minnesota and a combined population of at least 100 in Michigan and Wisconsin (in 2007 there were more than 3000 in Minnesota and more than 1000 in Wisconsin and Michigan combined) [40]. The recovery objective for wolves in the US Rocky Mountains, established in the 1987 recovery plan, has been exceeded since 2002 and in 2007 there were > fivefold more wolves than required for delisting [41]. Similarly, the recovery criteria for Yellowstone-area brown bears have been exceeded since 2000. The demographic delisting objective for brown bears in the Yellowstone area was to maintain at least 48 females with newborn cubs in the recovery area. These females had to be well distributed geographically and sustainable mortality quotas could not be exceeded. Challenges to delisting once the procedure's objectives have been achieved can have negative consequences for the ESA if these challenges result in reduced political and public support for the ESA and for species recovery efforts.

Alaska has unique management objectives for some large carnivores (wolves, brown bears and black bears). In 1994, the Alaska legislature passed an intensive management law that puts a priority on maximizing hunter harvests of moose and caribou. Since then, Alaska regulations in some popular moose and caribou hunting areas have been increasingly designed to reduce the abundance of large carnivores with the objective of increasing ungulate harvests [1,48,65]. This move to reduce carnivores in Alaska is a reversion

towards attitudes about predation that existed 50–100 years ago in the lower 48 states [66]. There is a resurgence of similar attitudes among some hunters toward large carnivores, especially wolves, in the lower 48 states where wolves have rapidly increased in the last 20 years. These resurgent, negative attitudes are also evident among ranchers exposed to increasing depredations of their livestock by recovering populations of wolves and brown bears. It seems that attitudes supporting increases of large predators may be partly a function of how often people have to deal with these animals. If predators continue to recover in the lower 48 states in areas where there are real or perceived impacts, attitudes will likely shift towards limiting predator numbers.

In parts of Canada, management objectives for wolves, and in some places cougars, are complicated by concerns regarding rapidly declining woodland caribou populations. Increasing rates of forest fragmentation (e.g. logging and hydrocarbon development) have led to increasing numbers of moose and deer that are adapted to early seral-stage vegetation and increases in these species have led, in turn, to increased wolf numbers. Unsustainable predation rates on caribou by a growing population of wolves combined with changes in caribou habitat represent serious challenges for caribou conservation [67,68]. Because late-seral forest conditions that are essential caribou habitat cannot be recovered quickly, predator reduction is likely to be a component of any management scheme option to aid recovery of woodland caribou [69–75]. In some areas, Canadian caribou biologists believe that wolf reductions will be a necessary component of caribou recovery efforts until early seral-stage habitat conditions mature and habitats, once again, become poor for deer and moose and good for caribou. Similarly, concerns exist about brown bear predation on declining muskoxen (*O. moschatus*) herds in northern Alaska, although the ultimate causes of muskoxen declines there are uncertain.

Habitat management

Public lands are critical to the conservation and management of large carnivores in North America because they represent large blocks of habitat that are, so far, relatively undisturbed. In the USA, federal land managers (e.g. US Forest Service, US Bureau of Land Management, National Park Service and USFWS for the National Wildlife Refuges) are required by the ESA to prioritize the recovery of ESA-listed species above commercial interests such as logging, grazing or recreational uses. In particular, Glacier National Park in Montana and Yellowstone National Park are vitally important centres for conservation and recovery of brown bears in the US Rocky Mountains. Likewise, Yellowstone National Park, the central Idaho wilderness areas and remote USDA Forest Service lands in the Great Lakes area are important for wolf recovery.

Under the ESA, the USA determined that the polar bear was threatened by habitat loss due to climate change throughout their entire range [30]. When polar bears were listed, however, specific exemptions were included that would preclude using the ESA listing as a tool for reducing the greenhouse gases causing their habitat (sea ice) to disappear. In 2009, the USFWS proposed 200,541 square miles of barrier islands, sea ice and terrestrial denning areas as critical habitat. Although it may not be too late to prevent polar bear extinction if greenhouse gas emissions are reduced sufficiently, this would require maintaining global mean temperature rise to less than 1.25° C and the window of time within which this can be accomplished, and polar bear extinction averted, is rapidly shrinking [4,9,27,28]. With polar bears listed as a ‘special concern’ species in Canada, the available

management responses are minimal and the species will remain under territorial and provincial jurisdiction despite the majority of their habitat, the sea ice, being the jurisdiction of the federal government.

Brown bears, black bears, cougars and wolves remain relatively abundant in Canada. For brown bears, at least, there is considerable support for provincial and territorial agencies to preserve suitable habitat conditions. Most efforts have been directed at limiting road access to reduce encounters between brown bears and people. Although protecting important habitats from developments continues in some areas, resource extraction interests usually dominate wildlife habitat protection efforts.

In the USA, tribal lands (reservations and designated traditional hunting areas) managed by Native Americans are important for wolf (Nez Perce Reservation in central Idaho) and brown bear recovery (e.g. Salish-Kootenai and Blackfeet reservations in western Montana). Tribal authorities traditionally valued, and currently put a high priority on, the conservation of species now listed under the ESA. Following reintroduction of wolves into central Idaho in 1995 and the unwillingness of the State of Idaho to play a role in wolf recovery, the Nez Perce tribe accepted primary responsibility for managing and researching the wolf population in central Idaho reintroduced in 1995.

In Canada, negotiations between government and First Nation groups regarding land ownership and management have reached a variety of settlements. Generally, in southern Canada, First Nation reserves are small in size, but are on high-value lands, and are often where the major permanent settlements were historically located (e.g. on lake shores, river confluences and oceanfront). These lands are too small to have a significant effect on carnivore management. Farther north, however, co-management agreements extend over much of the northern territories and some provinces. Management of large carnivores in the north is often part of well-established co-management boards with mandated involvement from land claim settlements. Quotas are established for brown and polar bears through a consultative process that includes both scientific and traditional knowledge. Privately owned lands used for production of commodities pose a special challenge for management of large carnivores in both Canada and the USA. Private lands become a mortality sink for large carnivores when conflicts arise because of the threats, real or perceived that large carnivores pose to economic interests or human safety. Brown and black bears, for example, are attracted to human garbage and foods. Food-conditioned bears are often killed legally by agencies or sometimes killed illegally by people adversely affected by the bears. In rural areas, bear awareness programmes promote the reduction of attractants, establish public education programmes and enforce regulations that are designed to reduce bear conditioning to human foods and garbage. Depredations on livestock by wolves, brown bears and cougars also frequently result in deaths (management removals) of offending animals on both private and public lands. Some private lands owned by wealthy conservation-oriented individuals like Ted Turner in the USA have become extremely important to the conservation of rare and endangered species, including wolves.

During 2000–2004, verified wolf kills of livestock south of Canada averaged 236/year compared to 552/year during 2005–2009; the increase again reflected the increasing numbers and distribution of wolves. Of these, 65% were sheep kills and 30% were cattle kills [41]. The National Wildlife Federation's Wildlife Conflict Resolution Program retires livestock grazing allotments on federally owned lands in the Yellowstone Ecosystem that experience conflict with wildlife, especially grizzly bears, wolves and bison. Ranchers choosing to participate in this programme receive fair payment for their allotments and secure grazing in other locations. As of 2011, this programme had retired 247,720 ha of

grazing allotments in areas with conflicts with large carnivores. In both Canada and the USA, many other environmental organizations collaborate with government agencies to reduce mortalities of carnivores near ranches.

Conflicts between people and large carnivores are frequently a consequence of habitat loss and alterations. Historically, wolves, brown bears, cougars and black bears lived in regions that are currently heavily occupied by people, their crops or their livestock. In such areas, it is often impossible for large carnivores to survive because of conflicts with human society, damages to property, dangers (real or perceived) to safety and insufficient secure habitat for carnivores, such as natural food or cover. Consequently, in regions with high densities of people, large carnivores are mainly restricted to islands of relatively wild habitats surrounded by a sea of human-dominated landscapes. Further, these island habitats are increasingly fragmented by roads or other incursions. In a similar manner, shrinking sea ice will create problems for polar bears as they are forced to spend more time ashore in close proximity to settlements.

Conclusion

The distribution and abundance of most large carnivore species declined dramatically in the USA, as well as central and eastern portions of Canada, during the last 200 years. Conservation and restoration efforts in both countries during the last half century have resulted in significant recovery of black bears and more localized recovery of cougars, wolves and brown bears. Polar bears have been less affected by human activities to date, but are poised on the brink of major declines caused by changes in their sea ice habitat.

During the historic period, no species of large carnivore has become extinct in North America, except the red wolf, which disappeared from the wild in 1980 before being re-established with captive animals. Numerous likely subspecies, however, have become extinct such as the brown bears and wolves that formerly occupied the Great Plains and the southeast (California, Mexico, Arizona, etc.). Although large carnivores remain abundant in Canada and Alaska, wolves came close to extirpation in the contiguous USA, but have recovered in two portions of the USA (the Great Lakes in the Midwest and the northern Rocky Mountains). Brown bears also came close to extinction in the US south of Canada in the 1960s, but are now recovering. Small populations of brown bears are precariously persisting in three other areas of the USA (northern Idaho, north western Montana, and, perhaps, in north western Washington) and in parts of southern Canada. The Selway-Bitterroot Wilderness in central Idaho and western Montana and the Cascade Mountains in north western Washington are recovery areas sufficiently large for viable brown bear populations [76] but, to date, re-establishing populations there lacks sufficient political support. Although black bears and cougars are extirpated from much of their historic ranges, they are secure in large areas of western North America; black bears are also secure in much of their distribution.

It is difficult to predict the effects of changing climates on ecosystems. Polar bear numbers will certainly decline and are likely to be extirpated from all, to most, of their range within 100 years unless action is taken soon to reduce greenhouse gases from current levels [4,6,24,27,77]. Black and brown bears are food- and habitat-generalists and are likely to be affected less and later by climate-induced shifts in habitat or food than species that are food- and habitat-specialists like polar bears. Likewise, cougars and wolves are generalist predators and are also less likely to be impacted by climate-induced shifts in the

abundance of prey species in the short term, at least. The likely northward redistribution of humanity in response to climate change and increased competition with wildlife for habitat may ultimately be the most significant implication of climate change for large carnivores.

Wildlife management efforts in North America have had mixed impacts on the conservation of large carnivores. The evolution of wildlife science (e.g. advances in population estimation, research and determination of sustainable harvest levels) has been positive. Hunters, through their fees and frequent support, have contributed substantially to the science of managing large carnivores. Some individual hunters and hunting groups, however, are against large carnivore restoration efforts while other hunting groups and hunters have played highly significant roles in recovery efforts. Opposition to large carnivore restoration by hunters is most often based on concerns over adverse impacts recovered carnivores will have on wild cervids, wild sheep or other preferred huntable species.

For North American large carnivores, reducing mortality by agency control actions may be more important than managing hunters. Management regimes currently in place are likely to allow large carnivores to persist and, sometimes, increase in abundance and re-colonize lost habitat. Directed re-establishment through reintroduction in currently unoccupied portions of former ranges has been achieved for black bears and wolves [1,78]. On the other hand, efforts in the late 1990s to reintroduce brown bears to their former range in wilderness areas in central Idaho and western Montana [79] were unsuccessful due to a lack of political support and no bears were reintroduced. Brown bear population augmentation efforts in southern British Columbia and adjacent Washington State have also stalled because of local opposition. For large carnivores, political and social barriers, as well as habitat limitations, significantly impede repopulating large portions of ranges formerly occupied by these species in North America [80]. Restoration of large carnivore populations in many more areas is possible, if there is sufficient public support and tolerance by local residents.

Because wildlife is a publicly owned resource in both Canada and the USA, all citizens of these nations have a stake in its management. This contrasts with the situation in many parts of the world where property owners have ownership rights to the wildlife living on their lands and have the authority to destroy wildlife species such as predators that they deem detrimental to their interests [3]. There can be little doubt that the system of public ownership of wildlife, the discouragement of market hunting for this publicly owned resource, the existence of large areas of publicly owned lands and the emergence of professionally trained wildlife managers to manage the public's wildlife have all played important roles in the recovery and continuing conservation of large carnivores in many parts of North America. These are components of what is known as the North American model of wildlife conservation [81].

Acknowledgements

We appreciate the helpful comments on earlier drafts by T. France and S. Scaggs by referees E. Bangs, D. Smith and M. Obbard, and by editorial staff M. Trindale, J. Weir and S. Mahoney. We thank S. Mahoney for asking us to prepare this manuscript. Support during manuscript preparation was provided by the National Wildlife Federation, the British Columbia Ministry of Forests, and the University of Alberta.

References

[1] Nie, M.A., 2003, *Beyond Wolves: The Politics of Wolf Recovery and Management* (Minneapolis, MN: University of Minnesota Press).
[2] Leopold, A., 1949, *A Sand County Almanac* (New York: Oxford University Press).
[3] Taber, R.D. and Payne, N.F., 2003, *Wildlife, Conservation, and Human Welfare* (Malabar, FL: Krieger).
[4] Derocher, A., 2012, *Polar Bears: A Complete Guide to their Biology and Behaviour* (Baltimore, MD: The Johns Hopkins University Press).
[5] Williams, C.K., Ericsson, G. and Heberlein, T.A., 2002, A quantitative summary of attitudes toward wolves and their reintroduction (1972–2000). *Wildlife Society Bulletin,* **30**, 575–584.
[6] Stirling, I. and Archibald, W.R., 1977, Aspects of predation of seals by polar bears. *Journal of the Fisheries Research Board of Canada,* **34**, 1126–1129.
[7] DeMaster, D.P. and Stirling, I., 1981, Ursus maritimus. *Mammalian Species,* **145**, 1–7.
[8] Amstrup, S.C., 2003, Polar bear. In: G.A. Feldhamer, B.C. Thompson and J.A. Chapman (Eds.) *Wild Mammals of North America, Biology, Management and Conservation*, 2nd ed. (Baltimore, MD: Johns Hopkins University Press), pp. 587–610.
[9] Stirling, I., 2011, *Polar Bears: The Natural History of a Threatened Species* (Markham: Fitzhenry and Whiteside).
[10] Pelton, M.R., 2003, Black bear. In: G.A. Feldhamer, B.C. Thompson and J.A. Chapman (Eds.) *Wild Mammals of North America, Biology, Management and Conservation*, 2nd ed. (Baltimore, MD: Johns Hopkins University Press), pp. 547–555.
[11] Schwartz, C.C., Miller, S.D. and Haroldson, M.A., 2003, Grizzly bear. In: G.A. Feldhamer, B.C. Thompson and J.A. Chapman (Eds.) *Wild Mammals of North America, Biology, Management and Conservation*, 2nd ed. (Baltimore, MD: Johns Hopkins University Press), pp. 556–586.
[12] Pierce, B.M. and Bleich, V.C., 2003, Mountain lion. In: G.A. Feldhamer, B.C. Thompson and J.A. Chapman (Eds.) *Wild Mammals of North America, Biology, Management and Conservation*, 2nd ed. (Baltimore, MD: Johns Hopkins University Press), pp. 744–757.
[13] Knopff, K.H., Knopff, A.A., Kortello, A. and Boyce, M.S., 2010, Cougar kill rate and prey composition in a multiprey system. *Journal of Wildlife Management,* **74**, 1435–1447.
[14] Mech, D.L., 1970, *The Wolf: The Ecology and Behavior of an Endangered Species* (Minnesota, MN: University of Minnesota Press).
[15] Paquet, P.C. and Carbyn, L., 2003, Gray wolf. In: G.A. Feldhamer, B.C. Thompson and J.A. Chapman (Eds.) *Wild Mammals of North America, Biology, Management and Conservation*, 2nd ed. (Baltimore, MD: Johns Hopkins University Press), pp. 467–481.
[16] U.S. Fish and Wildlife Service, ND, The Mexican wolf recovery program: progress report #12, reporting period: January 1-December 31, 2009. Available online at: http://www.fws.gov/southwest/es/mexicanwolf/.
[17] Herrero, S., 1985, *Bear Attacks, Their Causes and Avoidance* (Piscataway, NJ: Winchester Press).
[18] Beier, P., 1991, Cougar attacks on humans in the United States and Canada. *Wildlife Society Bulletin,* **19**, 403–412.
[19] McNay, M., 2002, Wolf-human interactions in Alaska and Canada: A review of the case history. *Wildlife Society Bulletin,* **30**, 831–843.
[20] Mattson, D., Logan, K. and Sweanor, L., 2011, Factors governing risk of cougar attacks on humans. *Human-Wildlife Interactions,* **5**, 135–158.
[21] Hebblewhite, M., 2011, Unreliable knowledge about economic impacts of large carnivores on bovine calves. *Journal of Wildlife Management,* **75**, 1724–1730.
[22] Boertje, R.D., Keech, M.A., Young, D.D., Kellie, K.A. and Seaton, C.T., 2009, Managing for elevated yield of moose in interior Alaska. *Journal of Wildlife Management,* **73**, 314–327.
[23] Feldhamer, G.A., Thompson, B.C. and Chapman, J.A. (Eds.), 2003, *Wild Mammals of North America: Biology, Management, and Conservation* (Baltimore, MD: The Johns Hopkins University Press).
[24] Durner, G.M., Douglas, D.C., Nielson, R.M., Amstrup, S.C., Mcdonald, T.L., Stirling, I., Mauritzen, M., Born, E.W., Wiig, O., DeWeaver, E., Serreze, M.C., Belikov, S.E., Holland, M.M., Maslanik, J., Aars, J., Bailey, D.A. and Derocher, A.E., 2009, Predicting 21st century polar bear habitat distribution from global climate models. *Ecological Monographs,* **79**, 25–58.
[25] Regehr, E.V., Lunn, N.J., Amstrup, S.C. and Stirling, I., 2006, Effects of earlier sea ice breakup on survival and population size of polar bears in Western Hudson Bay. *Journal of Wildlife Management,* **10**, 2674–2683.
[26] Hunter, C.M., Caswell, H., Runge, M.C., Regehr, E.V., Amstrup, S.C. and Stirling, I., 2010, Climate change threatens polar bear populations: a stochastic demographic analysis. *Ecology,* **91**, 2883–2897.
[27] Derocher, A.E., 2010, Climate change: the prospects for polar bears. *Nature,* **468**, 905–906.
[28] Amstrup, S.C., 2011, Polar bears and climate change: certainties, uncertainties, and hope in a warming world. In: R.T. Watson, T.J. Cade, M. Fuller, G. Hunt and E. Potapov (Eds.) *Gyrfalcons and Ptarmigan in a Changing World* (Boise, ID: The Peregrine Fund), pp. 11–20.
[29] Regehr, E.V., Hunter, C.M., Caswell, H., Amstrup, S.C. and Stirling, I., 2010, Survival and breeding of polar bears in the southern Beaufort Sea in relation to sea ice. *Journal of Animal Ecology,* **79**, 117–127.

[30] U.S. Fish and Wildlife Service, 2008, Endangered and threatened wildlife and plants; determination of threatened status for the polar bear (Ursus maritimus) throughout its range. *Federal Register,* **73** (95), 28212–28302.
[31] Servheen, C., 1999, Status and management of the grizzly bear in the lower 48 United States. In: C. Servheen, S. Herrero and B. Peyton (Eds.) *Bears: Status Survey and Conservation Action Plan* (Gland, Switzerland: International Union for Conservation of Nature), pp. 50–54.
[32] Clark, J.D., Huber, D. and Servheen, C., 2002, Bear reintroductions: lessons and challenges. *Ursus,* **13**, 335–345.
[33] Garshelis, D.L., Crider, D. and van Manen, F., 2008. *Ursus americanus*. In *IUCN 2011, IUCN red list of threatened species, version 2011.1* http://www.iucnredlist.org (accessed 26 August 2011).
[34] Hristienko, H. and McDonald, J.E.Jr., 2007, Going into the 21st century: a perspective on trends and controversies in the management of the American black bear. *Ursus,* **18**, 72–88.
[35] U.S. Fish and Wildlife Service, 2010, Nez perce tribe, national park service, Montana fish, wildlife & parks, Idaho fish and game, and USDA wildlife services. In C.A. Sime, and E.E. Bangs (Eds.) *Rocky Mountain Wolf Recovery 2009 Annual Report* (Helena, Montana: USFWS, Ecological Services), 59601. http://western-graywolf.fws.gov.
[36] U.S. Fish and Wildlife Service, 2011, Final rule to revise the list of endangered and threatened wildlife for the Gray Wolf (Canis lupus) in the western Great Lakes (December 28, 2011). Available online at: http://www.fws.gov/midwest/wolf/delisting/index.htm.
[37] Nowak, R.M., 2002, The original status of wolves in eastern North America. *Southeastern Naturalist,* **1**, 95–130.
[38] Koblmuller, S., Nord, M., Wayne, R.K. and Leonard, J., 2009, Origin and status of the Great Lakes wolf. *Molecular Ecology,* **18**, 2313–2326.
[39] Sonya, K.G., Wilson, P.J., Kung, T.K., Shami, K., Theberge, M.T., Theberge, J.B. and White, B.N., 2004, A genetic assessment of the eastern wolf (*Canis lycaon*) in Algonquin Provincial Park. *Journal of Mammalogy,* **85**, 625–632.
[40] U.S. Fish and Wildlife Service, 2009, Endangered and threatened wildlife and plants; Final rule to identify the western Great Lakes populations of grey wolves as a distinct population segment and to revise the list of endangered and threatened wildlife. *Federal Register,* **73**(62), 15070–15123.
[41] U.S. Fish and Wildlife Service, 2009, Endangered and threatened wildlife and plants; Final rule to identify the northern Rocky Mountain population of grey wolf as a distinct population segment and to revise the list of endangered and threatened wildlife. *Federal Register,* **74**(62), 15123–15188.
[42] Smith, D.W., Bangs, E.E., Oakleaf, J.K., Mack, C., Fontaine, J., Boyd, D., Jimenez, M., Pletscher, D.H., Niemeyer, C.C., Meier, T.M., Stahler, D.R., Holyan, J., Asher, V.J. and Murray, D.L., 2010, Survival of colonizing wolves in the Northern Rocky Mountains of the United States, 1982–2004. *Journal of Wildlife Management,* **74**, 620–634.
[43] Treeves, A. and Bruskotter, J.T., 2011, Gray wolf conservation at a crossroads. *BioScience,* **61**, 584–585.
[44] U.S. Fish and Wildlife Service, 2011b, *U.S. Fish and Wildlife Service concludes eastern cougar extinct.* Press release March 2, 2011. Available online at: http://www.fws.gov/northeast/ECougar/pdf/easterncougarnewsreleaseFINALR4.pdf.
[45] Kolenosky, B.B. and Strathearn, S., 1987, Black bear. In: M. Novak, J.A. Baker, M.E. Obbard and B. Malloch (Eds.) *Wild Furbearer Management and Conservation in North America* (Ontario: Ministry of Natural Resources), pp. 442–454.
[46] Peek, J., Dale, B., Hristienko, H., Kantar, K., Loyd, A., Mahoney, S., Miller, C., Murray, D., Oliver, L. and Soulliere, C., 2005, *Management of Large Mammalian Carnivores in North America* (Bethesda, MD: The Wildlife Society Technical Review 12-1. The Wildlife Society).
[47] Beck, T., Beecham, J., Beier, P., Hofstra, T., Hornocker, M., Lindzey, F., Logan, K., Pierce, B., Quigly, H., Ross, I., Shaw, H., Sparrowe, R. and Torres, S., 2005, *Cougar Management Guidelines, Cougar Management Working Group* (Bainbridge Island, WA: WildFutures).
[48] Miller, S.D., Schoen, J.W., Faro, J. and Klein, D.R., 2011, Trends in intensive management of Alaska's grizzly bears, 1980–2010. *Journal of Wildlife Management,* **75**, 1243–1252.
[49] Compiled from data presented by: Harper, P. (Ed.), 2006, *Wolf management report of survey-inventory activities 1 July 2002-30 June 2005* (Juneau, Alaska: Alaska Department of Fish and Game).
[50] Mech, D.L., 2010, Considerations for developing wolf harvesting regulations in the contiguous United States. *Journal Wildlife Management,* **74**, 1421–1424.
[51] Carbyn, L.N., 1987, Gray wolf and red wolf. In: M. Novak, J.A. Baker, M.E. Obbard and B. Malloch (Eds.) *Wild Furbearer Management and Conservation in North America* (Toronto: Ontario Ministry of Natural Resources), pp. 359–376.
[52] Robichaud, C.B. and Boyce, M.S., 2010, Spatial and temporal patterns of wolf harvest on registered traplines in Alberta, Canada. *Journal of Wildlife Management,* **74**, 635–643.
[53] Fuller, T.K., Mech, D. and Cochrane, J.F., 2003, Wolf population dynamics. In: L.D. Mech and L. Boitani (Eds.) *Wolves: Behavior, Ecology and Conservation* (Chicago, IL: University of Chicago Press)), pp. 161–190.

[54] Miller, S.D. and Tutterrow, L., 1999, Characteristics of non-sport mortalities to brown and black bears and human injuries from bears in Alaska. *Ursus,* **11**, 239–252.
[55] Treves, A., 2009, Hunting for large carnivore conservation. *Journal of Applied Ecology,* **46**, 1350–1356.
[56] Prestrud, P. and Stirling, I., 1994, The International Polar Bear agreement and the current status of polar bear conservation. *Aquatic Mammals,* **20**, 113–124.
[57] National Research Council, 1997, *Wolves, Bears, and their Prey in Alaska: Biological and Social Challenges in Wildlife Management* (Washington, DC: National Academy Press).
[58] Keech, M.A., Lindberg, M.S., Boertje, R.D., Valkenburg, P., Taras, B.D., Boudreau, T.A. and Beckmen, K. E., 2011, Effects of predator treatments, individual traits, and environment on moose survival in Alaska. *Journal of Wildlife Management,* **75**, 1361–1380.
[59] Miller, S.M., Miller, S.D. and McCollum, D.W., 1998, Attitudes toward and relative value of Alaskan brown and black bears to resident voters, resident hunters, and nonresident hunters. *Ursus,* **10**, 357–376.
[60] Treves, A. and Martin, K., 2011, Hunters as stewards of wolves in Wisconsin and the Northern Rocky Mountains, USA. *Society and Natural Resources,* **24**(9), 984–994.
[61] Morzillo, A.T., Mertig, A.G., Garner, N. and Liu, J., 2009, Evaluating hunter support for black bear restoration in east Texas. *Human Dimensions of Wildlife,* **14**, 407–418.
[62] Duda, M.D., Gruver, B.J., Jacobs, S., Mathews, T., Lanier, A., Augustus, O. and Bissell, S.J., 1998, *Wildlife and the American Mind: Public Opinion on and Attitudes Toward Fish and Wildlife Management* (Harrisonburg, VA: Responsive Management).
[63] Ballard, W.B. and VanBallenberghe, V., 1998, Moose-predator relationships: research and management needs. *Alces,* **34**, 91–105.
[64] Hayes, B., 2010, *Wolves of the Yukon* (Taufkirchen: Druckerei Fritz Kriechbaumer).
[65] Van Ballenberghe, V., 2006, Predator control, politics, and wildlife conservation in Alaska. *Alces,* **42**, 1–11.
[66] Schwartz, C.C., Swenson, J.E. and Miller, S.D., 2003, Large carnivores, moose and humans: a changing paradigm of predator management in the 21st century. *Alces,* **39**, 41–63.
[67] Bergerud, A.T. and Elliot, J.P., 1986, Dynamics of caribou and wolves in northern British Columbia. *Canadian Journal of Zoology,* **64**, 1515–1529.
[68] Wittmer, H.U., McLellan, B.N., Serrouya, R. and Apps, C.D., 2007, Changes in landscape composition influence the decline of a threatened woodland caribou population. *Journal of Animal Ecology,* **76**, 568–579.
[69] Seip, D.R., 1992, Factors limiting woodland caribou populations and their interrelationships with wolves and moose in southeastern British Columbia. *Canadian Journal of Zoology,* **70**, 1494–1503.
[70] McLoughlin, P.D., Dzus, E., Wynes, B. and Boutin, S., 2003, Declines in populations of woodland caribou. *Journal of Wildlife Management,* **67**, 755–761.
[71] Schaefer, J.A., 2003, Long-term range recession and the persistence of caribou in the *taiga*. *Conservation Biology,* **17**, 1435–1439.
[72] Wittmer, H.U., McLellan, B.N., Seip, D.R., Young, J.A., Kinley, T.A., Watts, G.S. and Hamilton, D., 2005, Population dynamics of the endangered mountain ecotype of woodland caribou (*Rangifer tarandus caribou*) in British Columbia, Canada. *Canadian Journal of Zoology,* **83**, 407–418.
[73] Wittmer, H.U., Sinclair, A.R.E. and McLellan, B.N., 2005, The role of predation in the decline and extirpation of woodland caribou. *Oecologia,* **144**, 257–267.
[74] Wittmer, H.U., Ahrens, R.N.M. and McLellan, B.N., 2010, Viability of mountain caribou in British Columbia, Canada: effects of habitat change and population density. *Biological Conservation,* **143**, 86–93.
[75] Latham, A.D.M., Latham, M.C., McCutchen, N.A., and Boutin, S., 2011, Invading white-tailed deer change wolf-caribou dynamics in northeastern Alberta. *Journal of Wildlife Management,* **75**, 204–212.
[76] Roy, J., Servheen, C., Kasworm, W. and Waller, J., 2001, Restoration of grizzly bears to the Bitterroot Wilderness: the EIS approach. In: D.S. Maehr, R.F. Noss and J.L. Larkin (Eds.) *Large Mammal Restoration: Ecological and Sociological Challenges in the 21st Century* (Washington, DC: Island Press), pp. 205–224.
[77] Amstrup, S.C., DeWeaver, E.T., Douglas, D.C., Marcot, B.G., Durner, G.M., Bitz, C.M. and Bailey, D.A., 2010, Greenhouse gas mitigation can reduce sea-ice loss and increase polar bear persistence. *Nature,* **468**, 955–560.
[78] Clark, J.P. and Smith, K.G., 1994, A demographic comparison of two black bear populations in the interior highlands of Arkansas. *Wildlife Society Bulletin,* **22**, 593–603.
[79] U.S. Fish and Wildlife Service, 2000, *Final Environmental Impact Statement: Grizzly Bear Recovery in the Bitterroot Ecosystem* (Missoula, MT: US Fish and Wildlife Service).
[80] Schwartz, C.C., 2001, The paradigm of grizzly bear restoration in North America. In: D.S. Maehr, R.F. Noss and J.L. Larkin (Eds.) *Large Mammal Restoration: Ecological and Sociological Challenges in the 21st Century* (Washington, DC: Island Press), pp. 225–229.
[81] Organ, J.F., Mahoney, S.P. and Geist, V., 2010, Born in the hands of hunters: the North American model of wildlife conservation. *The Wildlife Professional,* **4**(3), 22–27.