Chapter 11

Management and Conservation of Wildlife in a Changing Arctic Environment

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Summary

Climate changes in the Arctic in the past have had major influences on the ebb and flow in availability of wildlife to indigenous peoples and thus have influenced their distribution and the development of their cultures. Trade in animal parts, especially skins and ivory of marine mammals, and trapping and sale of fur-bearing animals go far back in time. Responsibility for management and conservation of wildlife in the Arctic falls heavily on the residents of the Arctic, but also on the global community that shares in the use of arctic resources. A sense of global stewardship toward the Arctic is critical for the future of arctic wildlife and its peoples.

This chapter, drawing on Chapters 7 to 9, emphasizes that throughout most of the Arctic, natural ecosystems are still functionally intact and that threats to wildlife typical for elsewhere in the world – extensive habitat loss through agriculture, industry, and urbanization – are absent or localized. There is increasing evidence that contaminants from the industrialized world to the south are entering arctic food chains, threatening the health and reproduction of some marine mammals and birds and the humans who include them in their diets. Protection of critical wildlife habitats in the Arctic is becoming recognized by those living inside as well as outside the Arctic as essential for both the conservation of arctic wildlife and its sustainable harvest by residents of the Arctic.

Management of wildlife and its conservation, as practiced in most of the Arctic, is conceptually different to that at lower latitudes where management efforts often focus on manipulation of habitats to benefit wildlife. The history of over-exploitation of marine mammals and birds for oil and skins to serve interests outside the Arctic is now being balanced by international efforts toward conservation of the flora and fauna of the Arctic, focusing on maintaining the Arctic's biodiversity and valuing its ecosystem components and relationships. Case studies from Russia and Canada focusing on harvest strategies and management of caribou (wild reindeer) highlight the complex nature of this species. One reports the development of a co-management system, involving shared responsibility between users of the wildlife and the government entities with legal authority over wildlife, giving local residents a greater role in wildlife management.

Throughout much of the Arctic, harvesting of wildlife for food and furs through hunting and trapping has been the most conspicuous influence that residents of the Arctic have had on arctic wildlife in recent decades. It was the overexploitation of wildlife during the period of arctic exploration and whaling, largely in the 18th and 19th centuries, that led to the extinction of the Steller sea cow in the Bering Sea and the great auk in the North Atlantic, and drastic stock reductions and local extirpation of several other terrestrial and marine mammals and birds. In regions of the Eurasian Arctic, the adoption of reindeer herding by indigenous hunting cultures led to the extirpation or marked reduction of wild reindeer (caribou) and drastic reductions of wolves, lynx, wolverines, and other potential predators of reindeer. Heavy grazing pressure by semi-domestic reindeer along with encroachment of timber harvest, agriculture, hydroelectric development, and oil and gas exploration have altered plant community structure in parts of the Fennoscandian and Russian Arctic. Large-scale extraction of nonrenewable resources accelerated in the Arctic during the latter half of the 20th century with impacts on some wildlife species and their habitats, especially in Alaska from oil production, in Canada from mining for diamonds and other minerals, and in Russia primarily from extraction of nickel, apatite, phosphates, oil, and natural gas. Among the factors that influence arctic wildlife, harvest of wildlife through hunting and trapping is potentially the most manageable, at least at the local level. Indigenous peoples throughout much of the North are asserting their views and rights in management of wildlife, in part through gains in political autonomy over their homelands. Arctic residents are now starting to influence when, where, and how industrial activity may take place in the Arctic. Part of this process has been the consolidation of the efforts of indigenous peoples across national boundaries to achieve a greater voice in management of wildlife and other resources through international groups such as the Inuit Circumpolar Conference and the Indigenous Peoples Secretariat of the Arctic Council. The stage appears to be set for indigenous peoples of the Arctic to become major participants in the management and conservation of arctic wildlife. The legal institutions, however, encompassing treaty and land rights and other governmental agreements vary regionally and nationally throughout the Arctic, posing differing opportunities and constraints on how structures for wildlife management and conservation can be developed.

This chapter provides examples from throughout the Arctic which show that conservation of wildlife requires sound management and protection of wildlife habitats at the local, regional, and national levels if the productivity of those wildlife populations upon which arctic peoples depend is to be sustained. Wildlife populations and their movements in both the marine and terrestrial environments transcend local, regional, and national boundaries, thus successful management and conservation of arctic wildlife requires international agreements and treaties. The chapter concludes that responsibility for maintaining the biodiversity that characterizes the Arctic, the quality of its natural environment, and the productivity of its wildlife populations must be exercised through global stewardship. Guidelines are provided for effective management and associated conservation of wildlife in a changing Arctic with emphasis on the complexity and limitations of managing wildlife in marine systems. The guidelines

also stress the need for development of regional land and water use plans as a basis for protection of critical wildlife habitats in relation to existing and proposed human activities on the lands and waters of the Arctic.

11.1. Introduction

What can be learned from present wildlife management systems in the Arctic that can be drawn upon to alter existing systems or to design new ones to more effectively deal with climate-induced changes, and other changes that may occur in the future? Climate is the driver of change that has been the primary focus of the Arctic Climate Impact Assessment, however, it is important to remember that changes from other causes are also underway within the Arctic and that these are also affecting arctic ecosystems, as well as the economies, lifestyles, and dependency on wildlife of people in the Arctic. Many of these changes will continue along similar trajectories into the future, influenced by changing climate. The effects of climate change on wildlife populations, their productivity, and their distributions, will increasingly threaten arctic wildlife at the species, population, and ecosystem levels. Systems for management and conservation of wildlife in the Arctic will face new challenges and must become adaptable to the changes taking place in the natural environment accelerated by climate change. However, management and conservation of wildlife serve human interests, therefore in addition to becoming adaptable to those changes taking place in the natural environment, efforts toward management and conservation of wildlife in the Arctic must also be adaptable to those changes taking place among human societies, both within the Arctic and within the global community as a whole.

The objectives of this chapter are:

- To present an overview of structures for management and associated conservation of wildlife of land and sea in the Arctic, emphasizing current functioning structures.
- To assess the effectiveness of existing structures for management and conservation of wildlife in the Arctic in view of wide variation in regional social, economic, and cultural conditions.
- To emphasize the role of indigenous people in management of wildlife and its conservation in the Arctic.
- To explain how the distinctive regional and cultural perspectives of arctic residents affect management and conservation of wildlife in the Arctic within the context of the broader perspectives of the Arctic by the global community.
- To assess the adaptability of existing structures for management and conservation of wildlife in the Arctic within the context of expected climate change, and in association with resource extraction, other industrial development, the local economy, and community life.

11.2. Management and conservation of wildlife in the Arctic

11.2.1. Background

The term "wildlife" is used in this chapter in the modern sense inclusive, relevant to the Arctic, of non-domesticated birds and mammals living primarily in natural habitats in both terrestrial and marine environments. Wildlife management is an applied science that had its main development in continental Europe and North America. Aldo Leopold pioneered the development of modern, science-based wildlife management in the United States early in the 20th century, publishing in 1933 the first college-level text on wildlife management (Leopold, 1933). The initial focus of wildlife management was on species hunted or harvested by humans and has been parallel to, but distinct from, fishery management. Where practiced in most countries of the world today, however, it encompasses all aspects of conservation of wildlife species (including amphibians and reptiles) whether hunted or not, and encompasses harvest regulation, habitat protection and enhancement, wildlife population inventory and monitoring, and related ecosystem dynamics and research. Aldo Leopold's writings on environmental ethics and philosophy (Leopold, 1938, 1949, 1953) have also played a major role in the developing conservation and environmental movements following the Second World War.

Wildlife provided the foundation for the establishment of people and the development of their cultures in the Arctic. Wildlife was the primary source of food for humans living in the Arctic, and provided materials for clothing, shelter, fuel, tools, and other cultural items. Arctic-adapted cultures show similarity but also diversity in their dependency on specific species of wildlife. Caribou and reindeer, both the wild and semi-domesticated forms (all are the same species, *Rangifer tarandus*, reindeer being the term used for the Eurasian forms, and caribou for those native to North America), are of primary importance to most inland dwelling peoples throughout the Arctic. Marine mammals support indigenous peoples in coastal areas of the Arctic. Birds are also important in the annual cycle of subsistence harvest of wildlife in most arctic environments. Many wildlife species of the Arctic that are migratory, especially birds, but also marine mammals and some caribou and wild reindeer herds, are dependent during part of their annual life cycles on ecosystems outside the Arctic. As a consequence, efforts to ensure the conservation and sustainable human harvests of migratory species require management and conservation efforts that extend beyond the Arctic. The indigenous peoples of the Arctic include the marine mammal hunting Iñupiaq and Inuit of Alaska, Canada, and Greenland; the Dene who hunt the caribou herds of arctic Canada; the hunting, fishing, and reindeer herding Saami of the arctic regions of Fennoscandia and adjacent Russia; the reindeer herding and woodland hunting Dolgans of the central Siberian Arctic; and nearly twenty other cultural groups present throughout the circumpolar region (see Chapter 12).

Past climate changes have had major influences on the ebb and flow in availability of wildlife to indigenous peoples and thus have influenced the distribution of indigenous peoples in the Arctic and the development of their cultures. The accelerated climate warming observed in recent decades (Chapters 2 and 4), however, is resulting in major and more rapid changes in the ecology of arctic wildlife (Chapters 7, 8, 9), necessitating reassessment of structures for the management and conservation of arctic wildlife. As northern cultures developed, including those of indigenous and non-indigenous arctic residents, their relationships to wildlife were also influenced beyond strictly subsistence dependency through trade or other economic relationships, both internal to their own cultures and with other cultures. Trade in animal parts, especially skins and ivory of marine mammals; the semi-domestication of reindeer; and trapping and sale of fur-bearing animals go far back in time. Over the last two to three centuries cash income has become important for indigenous and non-indigenous residents from selling meat and hides and as well as through home industries producing saleable craft items from animal parts (see Chapters 3 and 12). Arctic wildlife is valued by many living outside the Arctic for its attraction for viewing and photographing, especially whales, seabirds, polar bears (*Ursus maritimus*), and caribou; for incorporation in art depicting the arctic environment; and for associated tourism. Sport and trophy hunting of wildlife bring many to the Arctic, with associated economic benefits to local residents through services provided. Others value the Arctic through virtual recognition of and fascination for the role of wildlife species in the dynamics of arctic ecosystems, many of whom may never visit the Arctic but learn about arctic wildlife through the printed and visual media. Responsibility for management and conservation of wildlife in the Arctic clearly falls heavily on the residents of the Arctic, now especially through empowerment of indigenous people, but also on the global community that benefits from the exploitation of arctic resources and shares in the appreciation of the wildlife and other values of the arctic environment. A consequence of conservation efforts affecting wildlife and their habitats, generated largely outside the Arctic, has been the many "protected areas" (UNESCO Biosphere Reserves, national parks, wildlife refuges, nature preserves, and sanctuaries) established by arctic countries, often with the encouragement and support of international conservation organizations such as the Conservation of Arctic Flora and Fauna (CAFF), the World Conservation Union (IUCN), and the World Wide Fund for Nature (WWF). A sense of global stewardship toward the Arctic is critical for the future of arctic wildlife and its peoples.

11.2.2. Present practices

Throughout most of the Arctic, natural ecosystems are still functionally intact (see Chapters 7, 8, 9). Most threats to wildlife typical for elsewhere in the world – extensive habitat loss through agriculture, industry, and urbanization – are absent in much of the Arctic or are localized. Similarly, introduced and invading wildlife species are few throughout most of the Arctic and tend to be localized at the interface between forest and tundra. Changes, however, are accelerating. Contaminants from the industrialized world to the south have reached arctic food chains, threatening the health and reproduction of some wildlife, especially marine mammals and birds, and the humans who include them in their diet (AMAP, 1998a,b, 2002). Energy and mineral extraction developments in the Arctic, although localized and widely scattered, tend to be of large scale, for example the Prudhoe Bay oil field complex in Alaska, the mining and associated metallurgical developments in the Taymir and Kola regions of Russia, and the hydroelectric development in northern Quebec. These contribute to the pollution and contamination of the arctic waters, atmosphere, and lands and result in local loss of wildlife through habitat destruction, excessive hunting, and other cumulative impacts. Protection of critical wildlife habitats in the Arctic is becoming increasingly recognized as essential for both the conservation of arctic wildlife and management of its harvest by arctic residents as pressures from outside the Arctic for exploitation of its resources increase (CAFF, 2001a; NRC, 2003).

Management of wildlife and its conservation, as practiced in most of the Arctic, is conceptually different in the minds of arctic dwellers in contrast to most people living at lower latitudes where management efforts often focus on manipulation of habitats to benefit wildlife (Fig. 11.1). Thus, "management of wildlife" in the Arctic may seem to some inappropriate terminology that has

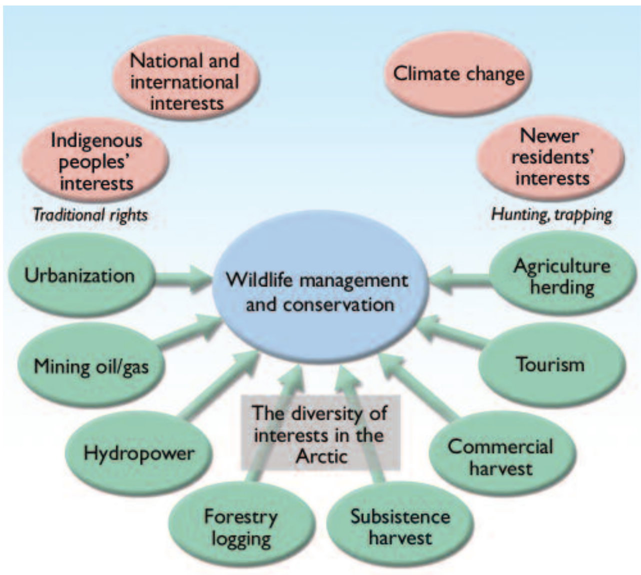

Fig. 11.1. Management and conservation of wildlife in the Arctic is driven by internal and external forces that involve wide-ranging interests and uses of wildlife. These include traditional harvest and dependency by indigenous peoples, the effects of resource extraction and associated industrial development, tourism, and valuation of wildlife at national and international levels through legal structures and conservation efforts.

developed through its application outside the Arctic. Arctic residents have often seen little justification for conventional wildlife management throughout much of the Arctic in the past, and have questioned the need for science-based wildlife management when harvest levels have posed little threat to sustained viability of the species harvested (e.g., Huntington, 1992). To the contrary, many arctic peoples see the current health of arctic ecosystems as evidence of their effectiveness as conservationists over the centuries and their often aggressive resistance in the past to commercial overexploitation of marine mammals and birds for oil and skins (Burch, 1998). Prior to the presence of Europeans in the Arctic, the archeological evidence indicates that communities and entire cultures either moved or died out as a consequence of changing climate and associated unsustainable levels of wildlife harvest (Knuth, 1967; Schledermann, 1996), as was also the case at lower latitudes (Grayson, 2001). As well, these perceptions grow from historical conditions of "internal colonialism" in which southern populations viewed the arctic resources as open to access and available for exploitation, contrasting to indigenous views of territoriality with soft borders and property held in common by groups (Osherenko and Young, 1989). In recent years, many indigenous residents have resisted systems for wildlife management and conservation imposed from outside the Arctic, particularly when these rely heavily on new and strange technologies and are based on tenets that are unfamiliar or inappropriate to arctic cultures (Klein, 2002).

Increased emphasis by those living outside the Arctic on conservation of the flora and fauna of the Arctic and associated emphasis on maintaining its biodiversity, and valuing all its ecosystem components and relationships, has understandably appeared hypocritical to many arctic indigenous peoples dependent on sustainable harvest of arctic wildlife (e.g., Freeman and Kreuter, 1994). Thus, some indigenous peoples have questioned the justification for wildlife management in the Arctic as a discrete aspect of ecosystem or land use management, when in much of the Arctic the need is for integrated land, coastal, and oceanic plans for management.

The legacy of relations and emergent conditions require the development of wildlife management approaches in the Arctic that foster collective action among a highly diverse set of stakeholders and also assume high ecological uncertainty (Jentoft, 1998; Young and Osherenko, 1993). Research on the sustainability of common property resources of the past two decades, which has questioned conventional approaches of "state control" as reflected in Hardin's (1968) *Tragedy of the Commons*, points to social institutions as key determinants of human behavior and ecological change (Berkes and Folke, 1998; Hanna et al., 1996; Ostrom, 1990; Ostrom et al., 2002; Young, 2001). The findings of institutional analysis identify design principles that are critical for effective institutional performance, and note how effective institutions of wildlife management can reduce transaction costs among actors and build trust among players. In some regions of the Arctic, the settlement of indigenous land claims has provided opportunities to create new institutional arrangements with these principles in mind, and thus giving local communities a greater role in the practice of wildlife management if not in determining the premises on which it is based (e.g., Adams et al., 1993; Berkes, 1989; Caulfield, 1997; Freeman, 1989; Huntington, 1992; Osherenko, 1988; Usher, 1995).

Throughout much of the Arctic, harvesting of wildlife for food and furs through hunting and trapping has, nevertheless, been the most conspicuous influence that residents of the Arctic have had on arctic wildlife in recent decades. It was the overexploitation of wildlife during the period of arctic exploration and whaling in the 18th and 19th centuries that led to the extinction of the Steller sea cow (*Hydrodamalis gigas*) in the Bering Sea and the great auk (*Pinguinus impennis*) in the North Atlantic, and drastic stock reductions and local extirpation of several other terrestrial and marine mammals and birds. In many regions of the Eurasian Arctic, the adoption of reindeer herding by indigenous hunting cultures led to the extirpation or marked reduction of wild reindeer and drastic reductions of wolves (*Canis lupus*), lynx (*Lynx lynx*), wolverines (*Gulo gulo*), and other potential predators of reindeer (Chapter 12). In recent decades heavy grazing pressure by semi-domestic reindeer has altered plant communities in parts of the Fennoscandian and Russian Arctic, that has in some areas been exacerbated by encroachment into traditional grazing areas of timber harvest, agriculture, hydroelectric development, and oil and gas exploration (e.g., Forbes, 1999). Large-scale extraction of nonrenewable resources accelerated in the Arctic during the latter half of the 20th century with consequences for some wildlife species and their habitats, especially in Alaska from oil production, in Canada from mining for diamonds and other minerals, and in Russia primarily from extraction of nickel, apatite, phosphates, oil, and natural gas (CAFF, 2001a).

Among the factors that influence arctic wildlife, harvest of wildlife through hunting and trapping is potentially the most manageable, at least at the local level. At a more regional level, these influences come through decisions on wildlife habitat as a land use issue. Indigenous peoples throughout much of the North are asserting their views and rights in wildlife management, in part through increased political autonomy over their homelands or involvement in cooperative management regimes (Caulfield, 1997; Huntington, 1992; Klein, 2002; Nuttall, 1992, 2000). However, people still feel largely limited in controlling the influences on wildlife and wildlife habitats brought about through climate change, or large-scale resource extraction in both the marine and terrestrial environments, changes largely resulting from the effects of, and pressures generated by, people living outside the Arctic. Similarly, arctic residents are generally poorly informed about conditions and management of migratory species in their wintering environments far from the Arctic, especially waterfowl

Box 11.1. The Inuit Circumpolar Conference

The Inuit Circumpolar Conference (ICC) defends the rights and furthers the interests of Inuit in Greenland, Canada, Alaska, and Chukotka – in the far east of the Federation of Russia. Established in 1977, the ICC maintains national offices in each of the four countries and has official observer status in the United Nations Economic and Social Council. Noted for its efforts to conserve and protect the environment and to promote sustainable development, the ICC also defends and promotes the human rights of Inuit, the Arctic's original inhabitants.

and some whale species, and seek greater involvement in management of migratory species governed by international treaties. The influence that Canadian arctic peoples had, however, in the negotiations leading to the 2001 Stockholm Convention on Persistent Organic Pollutants has shown the potential for concerted action by arctic peoples at the global level (Downie and Fenge, 2003).

Throughout most of the Arctic where efforts have been directed at conservation and management of wildlife, the primary focus has been on regulation of the harvest of wildlife to ensure the long-term sustainability of the wildlife populations and the associated human harvest from them. Secondly, protection of wildlife habitats from loss or degradation has been acknowledged as essential for the sustainability of wildlife populations, however, where large-scale development activity has occurred local interests in wildlife have often been poorly represented in land use decisions. Although there are similarities throughout much of the Arctic in the distribution of wildlife species and their use by humans, there are major local and regional differences in the importance of specific wildlife species in the local subsistence and cash economies. These differences relate to past traditions of use of wildlife, relative availability of wildlife for harvest, and the role that wildlife play in the local economy. For example, in Eurasia, commercial harvest of wildlife is generally supported by legal structures that assign wildlife ownership to the land owner, in contrast to North America where wildlife remains the property of the state and commercial harvest of wildlife is prohibited or discouraged.

Along with the increasing political autonomy of indigenous peoples in recent decades, these arctic residents are developing their capacity to influence when, where, and how industrial activity may take place in the Arctic. Part of this process has been the consolidation of the efforts of indigenous peoples across national boundaries to achieve a greater voice in management of wildlife and other resources through international groups such as the Inuit Circumpolar Conference (see Box 11.1) and the Indigenous Peoples Secretariat of the Arctic Council. In addition to the eight arctic countries that make up membership of the Arctic Council, indigenous organizations have representation as Permanent Participants of the Council and include the Russian Association of Indigenous Peoples of the North, the Inuit Circumpolar Conference, the Saami Council, the Aleutian International Association, the Arctic Athabaskan Council, and the Gwich'in Council International. Through the resulting increased political voice and sharing of interests, the stage appears set for indigenous peoples of the Arctic to become major participants in the management and conservation of arctic wildlife. The legal institutions, however, encompassing treaty and land rights and other governmental agreements vary regionally and nationally throughout the Arctic, posing differing opportunities and constraints on how structures for wildlife management and conservation can be developed.

Conservation of wildlife in the Arctic requires sound management and protection of habitats at the local, regional, national, and international levels if the productivity of those wildlife populations that arctic peoples are dependent upon is to be sustained. Wildlife populations and their movements in both the marine and terrestrial environments often transcend local, regional, and national boundaries, thus successful management and conservation of arctic wildlife, requiring scientific investigation, monitoring, and management action, must also transcend political boundaries through international agreements and treaties (CAFF, 2001a). Many of the pressures on arctic wildlife originate outside the Arctic, such as contaminants in marine wildlife, habitat alteration through petroleum and mining developments, and climate changes exacerbated by increased concentrations of greenhouse gases. It seems clear that responsibility for maintaining the biodiversity that characterizes the Arctic, the quality of its natural environment, and the productivity of its wildlife populations must be supported through a sense of stewardship at both the local and global levels.

11.2.3. The role of protected areas

A goal of ecosystem conservation in the Arctic as elsewhere is maintenance of the health of the unique complex of ecosystems that characterize the Arctic, and in doing so, to attempt to ensure the protection and sustainability of the unique biodiversity for which the Arctic is valued both by arctic residents and the rest of the world community. An important process in the efforts to achieve this goal has been the identification of natural habitats of critical importance in the life cycles of wildlife species, and their subsequent protection through legal processes at local, regional, national, and international levels of government. Although "protected areas" are often established with the well-being of a single species or a group of related species being the primary focus (e.g., Ramsar sites for waterfowl, Round Island in Alaska for walrus (*Odobenus rosmarus*); see Fig. 11.2), all

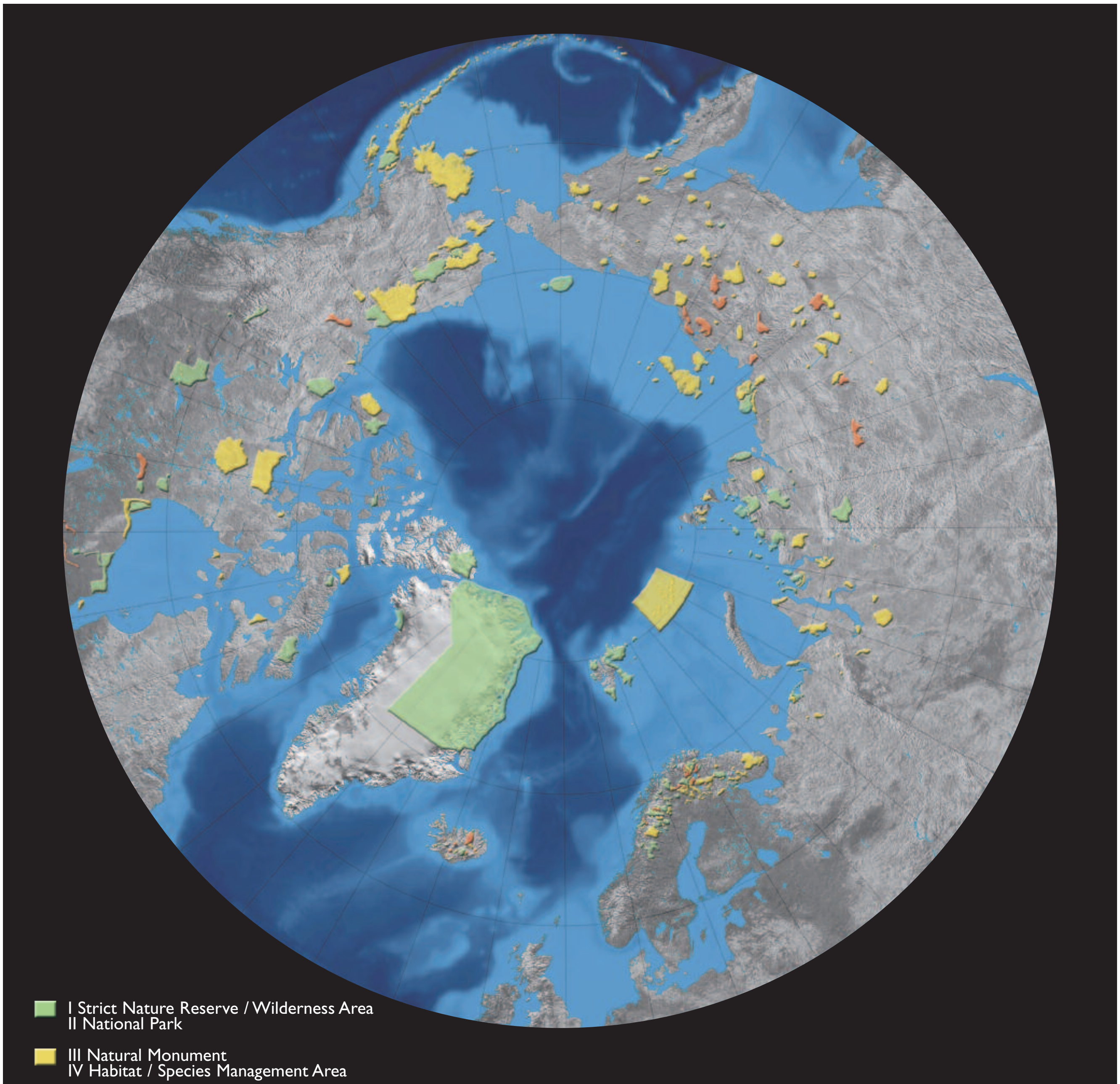

Fig. 11.2. Protected areas (>500 hectares) in the Arctic by IUCN Categories I-VI (compiled by UNEP-WCMC as quoted in CAFF, 2001a).

forms of life that are encompassed within these units generally benefit. Conversely, other areas may be protected primarily in recognition of the unique biodiversity that they encompass. In 1996, CAFF developed a Strategy and Action Plan for a Circumpolar Protected Area Network. Execution of the plan was designed to perpetuate the dynamic biodiversity of the arctic region through habitat conservation in the form of protected areas to represent arctic ecosystems, and to improve physical, informational, and managerial ties among circumpolar protected areas. As a result of CAFF's efforts, jointly with other international governmental and non-governmental organizations, and local, regional, and national governments and interests, nearly 400 protected areas (greater than 10 km^2) were established throughout the Arctic in 2000, totaling over 2.5 million km^2 (CAFF, 2001a).

Selection of areas needed for protection in the interest of wildlife conservation is not a task easily accomplished even when there is broad public and governmental support for the process. Identifying those areas of critical habitat needing protection for the effective conservation of wildlife in the Arctic requires comprehensive habitat inventories and assessment of all existing and proposed land uses within areas under consideration. Part of these assessments is the weighing up of consequences of the present and proposed uses of the areas under consideration for protection (e.g., subsistence, commercial, and sport hunting; reindeer grazing; transportation corridor construction; and other resource extraction uses). Establishment of protected areas critical to effective conservation of wildlife, and acceptance and respect for their legal protection, generally requires advance involvement, open discussion, and often compromise among all poten-

Box 11.2. Balancing nature conservation and industrial development in Canada

There should be no new or expanded large-scale industrial development in Canada until a network of protected areas is reserved which adequately represents the natural region(s) affected by that development. The Conservation First Principle (WWF Canada, 2001).

An essential element of conserving Canada's natural heritage is to permanently protect an ecologically viable, representative sample of each of the country's terrestrial and aquatic natural regions. These protected areas conserve a basic level of natural habitat for Canadian wildlife and the ecological processes that provide freshwater, fertile soils, clean air, and healthy animals and plants. In many places, these natural areas are crucial to the continued livelihoods and cultural integrity of Canada's indigenous peoples.

Protecting representative samples of every natural region in Canada should be accomplished in a way that fully respects the constitutional rights of indigenous peoples, and provides genuine economic opportunities for local residents. This goal can with careful planning be accomplished without sacrificing jobs or economic development.

Canada signed and ratified the international Convention on Biological Diversity in 1992. The same year, all Canadian Ministers responsible for wildlife, parks, the environment, and forestry (federally, provincially, and territorially) agreed in the Tri-Council Commitment to take a critical first step in conserving biodiversity by completing a network of ecologically representative protected areas in land-based natural regions by 2000, and by accelerating the protection of representative protected areas in Canada's marine natural regions.

The area of representative protected areas in Canada doubled in the 1990s, but the Tri-Council Commitment has not yet been met. Not all natural terrestrial regions have been moderately or adequately represented in protected areas, and marine regions remained largely unrepresented. Canadian government bodies have continued to approve new oil and gas leases, forest allocations, mining projects, hydro dams, and other large-scale development projects in Canada's natural habitats. WWF Canada (November 2001) stated that: "Every time a development project is proposed in a natural region that is not yet adequately represented by protected areas, we erode the options to establish these natural and cultural safeguards".

tial users of the areas and representatives of the governments with legal responsibility for their establishment. An example of the complex process for justification and establishment of protected areas for wildlife conservation was initiated in northern Yukon Territory of Canada and adjacent Alaska through an agreement between Canada and the United States establishing the International Porcupine Caribou Board. Through these international efforts a report on the sensitive habitats of the Porcupine Caribou Herd was prepared (IPCB, 1993) and is being used in an ongoing process of providing justification and protection of critical habitats within existing protected areas in Alaska and Yukon Territory, and in the regional planning process and establishment of additional protected areas in northern Yukon Territory. Non-governmental organizations can and have played an important role in the establishment of protected areas for wildlife conservation in the Arctic. Another example is the "Conservation First Principle" concept under development for the Canadian North through shared governmental and non-governmental efforts (see Box 11.2).

Protected areas set aside by governmental action, merely through establishment of their boundaries, do help to bring about public recognition of the importance of their role in wildlife conservation. Unless their establishment is accompanied by enforceable laws that govern their use, however, the areas remain protected in name only and remain vulnerable to overexploitation of the wildlife, and habitat alteration and destruction through competing land uses. Political pressures generated by large and often multinational industries interested in protected areas as loci for energy or mineral extraction, mass tourism, or other developments destructive to wildlife and their habitats, may be successful in persuading governments to allow them into these areas. Examples of where the protection offered to arctic areas set aside for wildlife conservation has been violated are widespread throughout the Arctic (e.g., seismic exploration for oil in the Arctic National Wildlife Refuge and atomic bomb testing in the Alaska Maritime National Wildlife Refuge, both in Alaska; illegal harassment of walrus in the Wrangel Island Reserve and uncontrolled poaching of wildlife in Kola Peninsula reserves by military personnel, both in Russia).

Although the importance of existing protected areas and the need for establishment of additional protected areas for effective conservation of wildlife in the Arctic are internationally recognized, climate change adds an additional layer of complexity in use of protected areas as a tool in wildlife conservation. If plants and animals change their distribution in response to a changing climate as is expected (Chapters 7, 8, 9), critical habitats of wildlife (seabird nesting colony sites, reindeer/caribou calving grounds, waterfowl and shore-bird nesting and staging areas, marine mammal haul-out areas) will also change in their distribution over time. Consequently, anticipating the needs for new protected areas important for conservation as wildlife and their habitats change in their distributions on the landscape will be an extremely difficult process. The process will necessarily need to be dynamic, with ongoing assessment of wildlife habitat use and dependency. This should enable recognition of the continued importance of some existing protected areas, and conversely, recognition that others that become abandoned by wildlife may no longer be needed, though they may retain value for protection of plant species or other ecosystem components. Wildlife management and conservation in an Arctic under the influence of climate change must be adaptive to ecosystem level changes that are not feasibly reversible within the human timescale, such as the northward movement of boreal ecotones into the Arctic along with the associated wildlife. Thus, protected areas will have value as areas where climate-induced or other externally influenced changes within ecosystems can be observed and monitored, free of major direct human impacts.

The establishment and use of protected areas is an essential component of conservation of wildlife and their habitats in the Arctic and in the protection of the biodiversity that characterizes arctic ecosystems. However, protected areas alone cannot ensure the sustained integrity of arctic ecosystems under the influences of a changing climate and accelerating pressures from resource extraction, tourism, and associated construction of roads, pipelines, and other transportation corridors. Of major concern is the fracturing of habitats through development activities, especially transportation corridors that may restrict the free movement and exchange of plants and animals between habitats even though significant parts of these habitats may have protected status. Ecological requirements for subpopulations of both plants and animals may be encompassed within protected areas, but the long-term integrity and sustainability of arctic ecosystems and the wildlife and other organisms within them requires opportunity for genetic exchange between components. Although critical habitat units may merit rigid protection, the intervening natural environment must be managed so that movement of species within entire ecosystems remains possible. Establishment of protected areas should be consistent with subsistence harvesting activities and not designed to exclude them. Management of the harvest of wildlife must be adaptable to changes that may take place in the population status of wildlife species.

Transportation corridors, especially roads and their associated vehicle traffic, may fracture habitats and limit free movement of species within ecosystems, however, they also provide corridors for the movement of invasive plant and animal species, with often detrimental consequences for native species with which they may compete, prey upon, parasitize, or infect. "Invasive species" is an all-inclusive generic term. It includes plants and animal species truly exotic to most regions of the Arctic and subarctic, such as the dandelion (*Taraxacum officinale*), house mouse (*Mus musculus*), and Norway rat (*Rattus norvegicus*) that have inadvertently been introduced by humans. There are, however, invasive species native to adjacent biomes, such as the moose (*Alces alces*) and snowshoe hare (*Lepus americanus*), that have expanded into parts of the North American Arctic from the boreal forest with consequences for arctic species and ecosystems. Humans have also been responsible for the deliberate introduction of plant and animal species into the Arctic. Examples are the introduction of lupine (*Lupinus* spp.) and coniferous trees to Iceland associated with erosion control and forest reestablishment, which through their subsequent dispersal have become nuisance species in areas where they crowd out native or introduced forage species for domestic livestock, and threaten preservation of the natural biodiversity. Among animals, the deliberate introduction of Arctic foxes (*Alopex lagopus*) to the Aleutian and Commander Islands in the 18th century for harvest of their pelts led to the marked reduction or extirpation of populations of marine birds, waterfowl, and other ground nesting birds. The intensive, decades-long efforts of the U.S. Fish and Wildlife Service to eliminate the Arctic foxes on many of the Aleutian Islands has resulted in rapid reestablishment of successful bird nesting on islands from which the foxes have been removed, but this has involved a great expenditure of effort and money. It can be expected that the appearance of invasive species in the Arctic will increase through deliberate and accidental human activities, as well as by natural dispersal assisted by transportation corridors and parameters of climate change that may favor the new species over native plants and animals.

It is important to remember that the decrease in biodiversity with increasing latitude that is a characteristic of arctic ecosystems is partly a consequence of the slow rate of dispersal of species into the Arctic following deglaciation. It is very likely that climate change, especially the climate warming projected to occur throughout much of the Arctic (see Chapter 4), and other forces will accelerate the "natural" movement of plant and animal species into the Arctic. It remains for human judgment to determine whether invading plant and animal species are to be considered part of the natural ongoing process of ecosystem change in the Arctic, whether they pose threats to the natural biodiversity of arctic ecosystems, or whether they are detrimental to human efforts to manage arctic ecosystems for human exploitation. Important tasks facing managers of wildlife in a changing Arctic will be assessing consequences for native species and ecosystems of the effects of invasive species within the constraints of a changing climate. It may also be necessary, where regionally appropriate, to develop procedures that restrict invasion of species that may have undesirable consequences for native species.

11.2.4. Change in human relationships with wildlife and managing human uses of wildlife

On the basis of early archeological evidence, human cultures with the technologies that allowed them to live under the climatic extremes of the Arctic while exploiting its marine resources did not appear until the mid-Holocene Epoch ~7000 years ago (Giddings, 1967). The entrance of humans to the Americas from Asia via Beringia 7000 to 8000 years earlier, however, occurred near the end of the Pleistocene Epoch when sea levels were lower, land areas greater, and the environment markedly different to how it later became in the Holocene (Meltzer, 1997). During much of the Holocene, following the first major wave of human movement into North America, as the Pleistocene ice retreated from the land, changes in human distribution, demography, culture, and movements were predominantly tied to changes in availability of wildlife. Humans located where species that were essential components of their diets, and provided materials for their clothing, shelter, tools, and weapons, were available. This pattern of human use of the land and adjacent sea prevailed as the Arctic was settled and cultures evolved in adaptation to the wildlife and other resources available for their exploitation (Schledermann, 1996; Syroechkovskii, 1995).

Wildlife species in both marine and terrestrial systems have undergone changes in their abundance and distribution in the past, and therefore in their availability for use by people in the Arctic. Some of these changes have resulted from heavy commercial exploitation of marine wildlife for their skins and oil and of terrestrial mammals largely for their pelts. Longer-term changes in distribution and abundance of wildlife in the Arctic are thought to have been largely the result of changes in climate affecting temperature, precipitation, snow characteristics, and sea-ice conditions and their influence on food chain relationships (see Chapters 7, 8, 9). All the peoples of the Arctic and the animals they hunt and use are subject to the vagaries of arctic climate. The global warming observed in the latter half of the 20th century, consistent with projections by general circulation models, has advanced most rapidly in certain parts of the Arctic, however, there have been regional inconsistencies (see Chapters 2, 4, 6). The western Canadian Arctic and the Alaskan Arctic have shown decadal temperature increases of 1.5 °C, whereas a nearly opposite cooling trend has been recorded in Labrador, northern Quebec, Baffin Island, and adjacent southwest Greenland (Serreze et al., 2000). Nevertheless, although some regions of the Arctic may not have experienced the pronounced warming in recent decades that has characterized most of the Arctic, changes in other climate-related parameters such as precipitation, frequency and severity of storm events, and thinning and reduced seasonal extent of sea ice are being observed in all regions of the Arctic (Chapter 2). Increases in ultraviolet-B (UV-B) radiation levels in the Arctic associated with thinning of the atmospheric ozone layer may have consequences for life processes of both plants and animals, however little is known of possible effects on wildlife (Chapter 7). However, to the extent that increased UV-B radiation levels may result in differential changes in tissue structure and survival of plant species, resulting in changes in their quality and abundance as food for herbivores, wildlife and their food chain relationships will be affected.

As a general rule the numbers of plant and animal species decline with increasing latitude from the equator to the poles, as does the complexity of species interrelationships and associated ecosystem processes. Since external influences tend to be buffered by the complexity of biological processes within ecosystems, the less complex arctic ecosystems can be expected to respond more dynamically to climate change than the more complex systems that exist at lower latitudes, and this seems to have been the case during past periods of climate change (Chapter 7). An additional compounding factor is that rates of climate-related change in much of the Arctic, reflected in climate warming and decrease in sea-ice thickness and extent, exceed those at lower latitudes.

11.3. Climate change and terrestrial wildlife management

11.3.1. Russian Arctic and subarctic

Hunting is an important part of the Russian economy, both through harvest of wildlife products and through pursuit of traditional sport and subsistence hunting. Fur production has been an essential part of the economy of the Russian North throughout history. Management of wildlife also has a long history in Russia, from early commercial and sport hunting to the creation of a complicated multifunctional state system under the Soviet government. Early attempts at regulation of hunting are known from the 11th century, and these attempts at wildlife management were connected with protection of species or groups of species. The first national law regarding hunting was imposed in 1892 as a reaction to widespread sport hunting, the establishment of hunter's unions, and the efforts of naturalists and others with interests in wildlife. These early efforts toward managing wildlife were based on wildlife as a component of private property.

Under the Soviet system, wildlife management developed on the basis of state ownership of all resources of the land, including wildlife, and a state monopoly over foreign trade and fur purchasing. Commercial hunting was developed as an important branch of production within the national economy. The state-controlled wildlife management system resulted in an elaborate complex of laws as the basis for governing commercial and sport hunting, for investigation of resources and wildlife habitats, for organization of hunting farms or collectives, for establishment of special scientific institutes and laboratories, for incorporation of scientific findings in wildlife management, and for the development of a system of protected natural areas. Justification for identifying natural areas deserving protection in the Russian Arctic became apparent as major segments of the Russian economy increased their dependence on exploitation of arctic resources during the Soviet period, stimulated by the knowledge that 70 to 90% of the known mineral resources of the country were concentrated in the Russian North (Shapalin, 1990). More than 300 protected natural areas of varying status were established for restoration and conservation of wildlife resources in the Russian Far North (Baskin, 1998).

Wildlife management was concentrated in a special Department of Commercial Hunting and Protected Areas within the Ministry of Agriculture. Local departments were organized in all regions of the Russian Federation for organization, regulation, and control of hunting with the intent to make them appropriate for actual conditions. Hunting seasons were established for commercial and sport hunting by species, regulation of numbers harvested, and designation of types of hunting and trapping equipment to be used. The major hunting activity was concentrated in specialized hunting farms. Their organization was initially associated with designated areas. The main tasks of the state hunting farms were planning, practical organization of hunting, and management for sustained production of the wildlife resources. At the same time, the system of unions of sport hunters and fishers was organized for regulation of sport hunting and fishing under the control of the Department of Commercial Hunting and Protected Areas (Ammosov et al., 1973; Dezhkin, 1978).

Commercial hunting has been primarily concentrated in the Russian Far North (tundra, forest–tundra, northern taiga), which makes up 64% of the total hunting area of the Russian Federation. During the latter decades of the Soviet system the Russian Far North produced 52% of the fur and 58% of the meat of ungulates and other wildlife harvested. The proportional economic value of the three types of resident wildlife harvested was 41% for fur (sable (*Martes zibellina*) – 50%, arctic fox – 9%, ermine (*Mustela erminea*) – 18%), 40% for ungulates (moose – 41%, wild reindeer – 58%), and 19% for small game (ptarmigan (*Lagopus* spp.) – 68%, hazel grouse (*Tetrastes bonasia*) – 15%, wood grouse (*Tetrao urogallus*) – 11%) (Zabrodin et al., 1989). Variation by region in characteristics of the harvest of wildlife in the Russian Arctic and subarctic is compared in Table 11.1. Participation in commercial hunting by the able-bodied local population was 25 to 30%. Profit from hunting constituted 52 to 58% of the income of the indigenous population. Of the meat of wild ungulates harvested, the amount obtained per hunter per year was 233 kg for professional hunters, 143 kg for semi-professional hunters, and 16 kg for novice hunters. The proportion of total wild meat harvested that was purchased by the state was 60%. Of that purchased by the state, 73% was for consumption by the local population. Fish has also been an important food resource for local populations, as well as for the professional hunters/ fishers. A professional hunter's family would use about 250 kg of fish per year, and 2000 kg of fish were required per year to feed a single dog team (eight dogs). By the end of the 1980s state purchase of wildlife and fish was 34% of potential resources, and local consumption was 27% (Zabrodin et al., 1989).

Indigenous residents of the Russian Arctic and subarctic have not had limitations on hunting for their subsistence use. However, all those engaged in professional, semi-professional, and sport hunting have been required to purchase licenses. Indigenous people involved in the state-organized hunting system were also provided with tools and consumer goods. The main problems that have confronted effective wildlife management in the Russian Arctic are widespread poaching, uneven harvest of wildlife, and loss of wildlife habitats and harvestable populations in connection with industrial development.

The wildlife management system in the Russian Arctic was not destroyed by the transformation of the political and economic systems that took place at the end of the

Table 11.1. Regional variation in wildlife harvest in the Russian Arctic and subarctic under the Soviet system (Zabrodin et al., 1989).

	European Russia	Western Siberia	Eastern Siberia	Northern Far East Russia
Share of area (%)	7	14	25	54
Ranking of relative biological productivity	4	2	1	3
Proportion of available resource harvested (%)	23	48	76	63
Expenditure (%)	9	15	34	42
Breakdown of value by species within region				
Fur				
Sable (%)	–	14	24	23
Polar fox (%)	5	7	3	4
Ungulate				
Moose (%)	15	18	12	20
Wild reindeer (%)	4	8	42	15
Game				
Partridge (%)	51	26	4	8
Distribution of the harvest				
Purchased by the state (%)	33	37	61	58
Local consumption (%)	67	63	39	42

20th century, but it was weakened. Partly as a consequence of this weakening, but also due to expansion of industrial development in the Russian Arctic and the effects of climate change, there has been the development of several major threats to effective wildlife conservation.

- Transformation of habitats in connection with industrial development. From an ecological standpoint the consequences of industrial development affect biological diversity, productivity, and natural dynamics of ecosystems. As far as environmental conditions are concerned it is important to note that apart from air and water pollution there is a possibility of food pollution. In terms of reindeer breeding, hunting, and fishing, industrial development has resulted in loss of habitats and resources, a decrease in their quality and biodiversity, and destruction of grazing systems (Dobrinsky, 1995, 1997; Yablokov, 1996; Yurpalov et al., 2001). A considerable portion of the biological resources presently exploited is from populations outside regions under industrial development (Yurpalov et al., 2001).
- Reduction in wildlife populations as a result of unsystematic and uncontrolled exploitation through commercial hunting.
- Curtailment of wildlife inventory and scientific research, resulting in loss of information on population dynamics, health, and harvest of wildlife.
- Changes in habitat use by wildlife, in migration routes, and in structure and composition of plant and animal communities as a consequence of climate change. Such changes include increased frequency and extent of fires in the northern taiga, displacement northward of active breeding dens of the Arctic fox on the Yamal Peninsula (Dobrinsky, 1997), as well as in other areas (Yablokov, 1996), and replacement of arctic species by boreal species as has occurred in the northern part of the Ob Basin (Yurpalov et al., 2001).

Both commercial and sport hunting are permitted throughout the Russian North. Commercial hunting for wild reindeer for harvest of velvet antlers is permitted for 20 days in the latter part of June. Commercial hunting of reindeer for meat can take place from the beginning of August through February. Sport hunting is permitted from 1 September to 28 February. A license is required to hunt reindeer (cost for sportsmen about US$4, for commercial enterprise about US$3). There are no restrictions on numbers of reindeer to be hunted. Hunting is permitted everywhere, with the exception of nature reserves. Regional wildlife harvest systems are compared in Table 11.2, together with associated wildlife population trends, threats to wildlife and their habitats, and conservation efforts.

In recent years in the Russian North, marketing of venison experienced an economic revival. In mining settlements in 2001 the cost of venison commonly approached US$2.5 per kilogram, making commercial hunting of reindeer potentially profitable. A significant demand has also existed for velvet antlers. However, under existing conditions in most of the Russian North where there are no roads and settlements are few, hunting of wild reindeer at river crossings remains the most reliable and productive method of harvest (see the case study on river crossings as focal points for wild reindeer management in the Russian Arctic in Box 11.3). Additionally, concentration of hunting effort at specific river-crossing sites provides an opportunity to influence hunting methods and for monitoring the number of animals killed. A proposal has been made to protect the traditional rights of indigenous hunters by granting them community ownership of some of the reindeer river crossings. This would presumably allow them to limit increasing competition from urban hunters for the reindeer. At present, indigenous people hunt reindeer only for their personal or community needs, but as owners of reindeer harvest sites at river crossings they would have a basis for developing a commercial harvest. Some large industrial companies have indicated a readiness to support commercial harvest of reindeer by indigenous people by assisting in the transportation of harvested reindeer to cities and mining settlements. Already, there are plans to open some of the more accessible river crossings for hunting by people from nearby towns and this will include personal use as well as commercial sale of the harvested reindeer. However, there is a need for development of regulations to prevent excessive harvesting of the reindeer and associated alteration of their migration routes. The inability in the past to predict the availability over extended periods of time of wild reindeer for human harvest because of their natural long-term population fluctuations led many indigenous peoples in the Arctic to include more than one ecologically distinct resource (e.g., reindeer and fish)

Fig. 11.3. Harvesting by indigenous people of wild reindeer in the Russian North and caribou in North America was traditionally done at river crossings on migration routes. This continues to be an efficient method of hunting reindeer and caribou in some regions, a hunting system that lends itself to managed control of the harvest.

as their primary food base. Similarly, a balance between harvest of reindeer for local consumption and commercial sale in communities in the Russian North would appear to offer greater flexibility for management of the reindeer and sustainability of local economies than large-scale commercial harvesting of reindeer. Flexibility in options for management of wild reindeer will be essential in the Arctic of the future that is expected to experience unpredictable and regionally variable ecological consequences of climate change. Increased adaptability of the arctic residents to climate change will be best achieved through dependence on a diverse resource base. This applies to the monetary and subsistence economies of arctic residents, as well as to the species of wildlife targeted for management, if wildlife is to remain an essential base for community sustainability.

Changes have occurred over time in methods and patterns of harvesting wild reindeer in the Russian North and these changes provide perspective on wildlife management in a changing climate. Since prehistoric times indigenous peoples throughout Eurasia and North America have hunted wild reindeer and caribou during their autumn migration at traditional river crossings. Boats were used to intercept the swimming animals where they were killed with spears (Fig. 11.3).
This method of harvesting wild reindeer may offer potential for management of wild reindeer under the

Table 11.2. Comparison of wildlife harvest systems in the Russian North.

Harvest system	Wildlife population trends	Threats to wildlife and their habitats	Conservation efforts
Kola Peninsula			
Hunting for subsistence and for local market sales	Over-harvest of ungulates, drastic decline in wild reindeer	Over-harvest of ungulates by military and for subsistence, fracturing of habitats by roads and railroads, habitat degradation from industrial pollution	Laplandsky Reserve (1930) 2784 km^2. Pasvik Reserve (1992) 146 km^2 (International, with Norway's Oevre Pasvik Park 66.6 km^2)
Nenetsky Okrug, Yamal, Gydan			
Intensive reindeer husbandry, control of large predators, incidental subsistence hunting, Arctic fox trapping	Decline in wolves, wolverines, and foxes	Over-grazing by reindeer, habitat damage by massive petroleum development with roads and pipelines, hunting by workers, control of predators	Nenetsky Reserve (1997) 3134 km^2 (near Pechora delta – waterfowl and marine mammals)
Khanty-Mansiysky Okrug			
Hunting focus on wild reindeer, moose, and furbearers; indigenous hunting culture in decline	Low hunting pressure, populations stable	Industrial development, forest and habitat destruction, fragmentation by roads and pipelines, pollution from pipeline leaks	Reserves: Malaya Sosva 2256 km^2, Gydansky 8782 km^2, Yugansky 6487 km^2, Verkhne-Tazovsky 6133 km^2
Taymir			
Hunting focus on wild reindeer and waterfowl, mostly subsistence, commercial harvest of velvet antlers at river crossings, restrictions limiting commercial antler harvest being enforced	Decline or extirpation of wild reindeer subpopulations near Norilsk, inadequate survey methods	Wild reindeer total counts are basis for management; lack of knowledge of identity and status of discrete herds; extensive habitat loss from industrial pollution; habitat fracturing and obstructed movements by roads, railroad, pipelines, and year-round ship traffic in Yenisey River for metallurgical and diamond mining, and oil and gas production	Reserves: Putoransky 18 873 km^2, Taimyrsky 17 819 km^2, Bolshoy Arctichesky 41 692 km^2; region-wide ecosystem/ community sustainability plan being developed
Evenkiya			
Hunting for subsistence and local markets, primarily moose, wild reindeer, and bear, little trapping effort	Little information, assumed stable	Low human (Evenki) density and poor economy result in little threat at present to wildlife and habitats	Need is low due to remoteness and low population density. No nature reserves
Yakutia (Sakha)			
Hunting primarily for wild reindeer, moose, snow sheep, and fur bearers, heavy commercial harvest as well as for subsistence, decline of reindeer herding increases dependency on subsistence hunting	Heavy harvest of reindeer and snow sheep for market results in population declines, introduced muskox increasing	Diamond mining provides markets for meat leading to over-harvest and non-selective culling, decrease in sea ice restricts seasonal migrations of reindeer on Novosiberski Islands to and from mainland	Ust Lensky Reserve 14 330 km^2. Muskox introduction adds new species to regional biodiversity and ecosystem level adjustments
Chukotka			
Wild reindeer, snow sheep, and marine mammals hunted for subsistence by Chukchi and Yupik people	Increases in wild reindeer, snow sheep, and large predators with decline in reindeer herding, muskoxen on Wrangel Island increasing	Major decline in reindeer herding, movement of Chukchi to the coasts, poor economy, and low extractive resource potential results in greatly reduced threats to wildlife inland from the coasts, increased pressure on marine mammals for subsistence	Reserves: Wrangel Island 22 256 km^2, Magadansky 8838 km^2, Beringia International Park – proposed but little political support

Box 11.3. River crossings as focal points for wild reindeer management in the Russian Arctic

Harvesting wild reindeer at river crossing sites (see Fig. 11.3) has played a significant role in regional economies and the associated hunting cultures in the Russian North (Khlobystin, 1996). Many crossing sites were the private possession of families (Popov, 1948). When reindeer changed crossing points it sometimes led to severe famine, and entire settlements vanished (Argentov, 1857; Vdovin, 1965). Such changes in use of migration routes are thought to result from fluctuations in herd size and interannual climate variability. Under the Soviet government, large-scale commercial hunting at river crossings displaced indigenous hunters.

Importance of river crossings for wild reindeer harvest

On the Kola Peninsula and in western Siberia there are few known locations for hunting reindeer at river crossings. In Chukotka, a well-known place for hunting reindeer was located on the Anadyr River at the confluence with Tahnarurer River. In autumn, reindeer migrated from the tundra to the mountain taiga and hunters waited for them on the southern bank of the Anadyr River. Reindeer often select different routes when migrating from the summering grounds. Indigenous communities traditionally arranged for reconnaissance to try to predict the migration routes. In Chukotka, mass killing sites at river crossings were known only in the tundra and forest–tundra, not in the taiga (Argentov, 1857). In Yakutia, reindeer spend summers on the Lena Delta where forage is abundant and cool winds, and the associated absence of harassment by insects, provide favorable conditions for reindeer. In August–September, as the reindeer migrate southwestward, hunters wait and watch for them on the slightly elevated western bank of the Olenekskaya Protoka channel of the Lena Delta where the reindeer traditionally swim across the channel. In the Taymir, 24 sites for hunting reindeer by indigenous people were located along the Pyasina River and its tributaries (Popov, 1948). The killing sites at river crossings occupy fairly long sections of the river. In more recent times when commercial slaughtering occurred, hunter teams occupied sections 10 to 20 kilometers long along the river and used observers to signal one another by radio about approaching reindeer; motor boats carrying the hunters then moved to points on the river where hunting could take place (Sarkin, 1977). In the more distant past, hunters used canoes and needed to be more precise in determining sites and times of the reindeer crossing. Reindeer are very vulnerable in water, and although their speed in water is about 5.5 km/hr (Michurin, 1965) humans in light boats could overtake the animals. In modern times, using motorboats and rifles, hunters were able to kill up to 70% of the animals attempting to cross the rivers at specific sites. A special effort was made to avoid killing the first reindeer entering the water among groups approaching the river crossings. Experience showed that if the leading animals were shot or disturbed those following would be deflected from the crossing. Conversely, if the leading animals were allowed to cross, following animals continued to cross despite disturbance by hunting activities (Savel'ev, 1977).

recent drastic changes that have taken place in social and economic conditions among the indigenous peoples of the Russian North resulting from the dissolution of the Soviet Union. Can management of wild reindeer through harvesting primarily at river crossings ensure sustainable harvests from the large migratory herds under conditions of human social and economic change compounded by the effects of climate change on the reindeer and their habitats? Addressing this question may be possible by comparing the population dynamics of reindeer and caribou herds in regions of the Arctic with differing climate change trends (Post and Forchhammer, 2002; Human Role in Reindeer/Caribou Systems project, see www.rangifer.net).

11.3.2. The Canadian North

11.3.2.1. Historical conditions and present status

In comparison to ecosystems at lower latitudes in Canada most ecosystems in the Canadian Arctic are considered functionally intact, although the consequences for marine ecosystems of contaminants introduced from industrial activity to the south and climate-induced thawing are not known. Most threats typical for elsewhere in the world – such as habitat loss through agriculture, industry, and urbanization – are localized. Introduced species primarily associated with agriculture at lower latitudes are scarce, or largely confined to areas near communities. Invasive wildlife species from the south, such as moose and snowshoe hares, are primarily restricted to the tundra–forest interface. Within most arctic ecosystems, resource use through hunting is the most conspicuous influence that people have on wildlife with the exception of localized resource extraction and expanding tourism. Among the factors that can influence arctic wildlife, hunting is potentially the most manageable and its quantitative assessment needed for management is feasible. Although hunting is not currently considered a threat to terrestrial wildlife in the Canadian Arctic, it has recently interacted with other factors such as weather to locally reduce caribou abundance on, for example, some arctic islands (Gunn et al., 2000). Managed hunting is considered an important part of wildlife conservation through its emphasis on sustainability of harvest. Hunting, however, poses a threat when it causes or contributes to undesired declines or through interaction with other species with detrimental consequences. The latter is especially rele-

Commercial harvest at river crossings

During the Soviet period, large-scale commercial harvest of reindeer at river crossings displaced indigenous hunters from these traditional hunting sites (Sarkin, 1977; Zabrodin and Pavlov, 1983). In Yakutia, after commercial hunting began in the 1970s, hunting techniques included the use of electric shocks to kill reindeer as they came out of the water. In recent years these commercially harvested reindeer populations in Yakutia declined precipitously (Safronov et al., 1999). In the Taymir, indigenous people practiced subsistence hunting at river crossings until the 1960s. However, by 1970, hunting regulations had banned hunting at river crossings by indigenous people and other local residents because of concern that over-harvest of the reindeer would occur. The Taymir reindeer increased greatly in the following years. Biologists working with the reindeer proposed reinstatement of the traditional method of killing animals at river crossings in order to establish a commercial harvest from the large Taymir population and to stabilize the population in line with the carrying capacity of the available habitat. The Taymir state game husbandry system was established by 1970. Up to 500 hunters participated in the annual harvests. All appropriate river hunting locations on the Pyasina River and the Dudypta, Agapa, and Pura tributaries were taken over for the commercial harvests. Large helicopters and in some cases refrigerated river barges were used to transport reindeer carcasses to markets in communities associated with the Norilsk industrial complex. Over a period of 25 years about 1.5 million reindeer were harvested by this system (Pavlov et al., 1993). After 1992, there was a decrease in the number of reindeer arriving at most of these river crossings, resulting in an abrupt decline in the harvest from about 90000 per year in peak years to about 15000 per year in subsequent years. This was associated with the disproportionate harvest of female reindeer (Klein and Kolpashchikov, 1991).

Consequences of climate change

Climate change may affect river crossings as sites for controlled harvest of reindeer in several ways. If patterns of use of summering areas change in relation to climate-induced changes in plant community structure and plant phenology then migratory routes between summer and winter ranges may also change. Thus, some traditional crossings may be abandoned and new crossings established. Changes in the timing of freeze-up of the rivers in autumn at crossing sites may interfere with successful crossings by the reindeer if the ice that is forming will not support the reindeer attempting to cross. These conditions have occurred infrequently in the past in association with aberrant weather patterns; however timing of migratory movements would also be expected to change with a consistent directional trend mirroring seasonal events.

vant in marine systems where knowledge of ecosystem relationships and processes are less well understood than they are for terrestrial systems. Hunting remains inextricably part of the long relationship between indigenous people of the Arctic and their environment, and they see themselves as part of the arctic ecosystems within which they dwell (Berkes and Folke, 1998).

Fluctuations in caribou numbers over decades in the Canadian Arctic have been a frequently reiterated observation in indigenous knowledge (e.g., Ferguson and Messier, 1997), and this parallels archaeological evidence from western Greenland (Meldgaard, 1986). The increased hunting that followed European colonization, with the introduction of firearms and commercial hunting, accentuated or over-rode natural fluctuations in caribou numbers and contributed to the so-called caribou crisis of low numbers between 1949 and 1955 (Kelsall, 1968). Subsequently, the herds of barren-ground caribou increased five-fold. The number of caribou on the mainland tundra in four of the largest herds (Bathurst, Beverly, Qamanirjuaq, and Bluenose) was estimated at 1.4 million in the mid-1990s and numbers are believed to be remaining relatively stable.

Historically, muskoxen (*Ovibos moschatus*) were sufficiently numerous to be an important part of the indigenous culture on the mid-arctic islands, but were less so on the mainland until a brief pulse in commercial hunting for hides in the late 1800s and early 1900s (Barr, 1991). However, sharp declines in muskox numbers on the Northwest Territories (NWT) mainland followed unregulated commercial trade in muskox hides. Muskox numbers quickly collapsed and within 30 years only a handful of scattered herds remained on the mainland. Muskox hunting was banned between 1917 and 1967, after which populations had started to recover by the 1970s when subsistence hunting was resumed under quotas. Numbers of muskoxen in the NWT and Nunavut have been recently estimated at about 100000 on the arctic islands and about 20000 on the mainland (Gunn and Fournier, 1998).

Hunting was not the cause of all known historic wildlife declines – muskoxen virtually disappeared from Banks and western Victoria Islands in the late 1800s, before European influences. Inuvialuit elders have memory from their youth of an icing storm that encased vegetation in ice and many muskoxen died on Banks Island (Gunn et al., 1991). Muskox numbers rebounded on Banks Island from a few hundred to 3000 by 1972 and to 64 000 by 2001 (Nagy et al., 1996; J. Nagy pers. comm., 2001).

The number of polar bears killed by hunters increased with European exploration and trading in the Canadian Arctic. Hunting for hides was not significant until the 1950s when prices climbed in response to market demands. Snow-machines were becoming available in the 1960s, leading to increased hunting and stimulating international concern over sustainability of the polar bear harvest. In 1968, regulations imposed quotas to reduce hunting of polar bears. Canada has about 14 800 polar bears of the entire arctic population of 25 000 to 30 000 bears (IUCN Polar Bear Specialist Group, 1998).

11.3.2.2. Present wildlife management arrangements and co-management

The federal and territorial governments responded to the wildlife declines in the NWT during the first half of the 20th century with well-meaning but mostly poorly explained regulations that restricted hunting. These regulations largely ignored local knowledge and emphasized hunting as a threat, which alienated indigenous hunters and left them feeling bitter. Those feelings still influence discussions about hunting, although changes in management practices as a result of establishing new management regimes in recent years may be reducing mistrust (Kruse et al., 2004; Richard and Pyke, 1993; Usher, 1995).

Co-management is a type of regime that has emerged in response to such conditions of conflict and mistrust to shift power and responsibility to boards comprising wildlife users, as well as government representatives. Co-management agreements establish boards of user representatives and agency managers, and typically have authority for wildlife management subject to conservation, public safety, and public health interests. Although overall authority for management is vested in the appropriate government ministry and/or indigenous governing organization, co-management boards make day-to-day decisions on wildlife and are valuable in assessing problems, achieving regional consensus, and making recommendations to user communities, management agencies, and government policy-makers. Co-management potentially helps to ensure that indigenous ecological knowledge is included in wildlife management, although there is debate over its effectiveness in this regard (Usher, 1995). Under land claims legislation, the territorial government determines a total allowable harvest using species-specific methods and recommends to the boards the allowable harvest for species that are regulated. If the total allowable harvest exceeds the basic needs levels, then the surplus can be allocated to non-beneficiaries or for commercial wildlife harvest, including sale of meat and guided hunts for non-resident sport/trophy hunters.

The NWT and Nunavut territorial governments use a variety of methods for determining allowable harvest. Differences in methodology are a complex of practicality, species life history, and management history. For caribou and muskox harvest management, pragmatic flexibility often takes precedence over application of theory (Caughley, 1977; Milner-Gulland and Mace, 1998). Aerial surveys are used to track caribou and muskox population trends. For barren-ground caribou, the survey findings have not been used to limit subsistence hunting, although they have been used to set quotas for commercial use. In a few instances, communities voluntarily took action to reduce hunting on some arctic islands, based on hunter reports of decline in caribou numbers. In contrast to caribou, muskoxen are hunted under an annual quota based on a 3 to 5% harvest of the total muskoxen estimated within the management unit. The local community decides whether the quota is for subsistence or commercial use.

Managing polar bears has taken a different direction from managing caribou and muskoxen, at least partly because tracking polar bear abundance is logistically difficult and prohibitively expensive. The total allowable harvest is based on modeling the maximum number of female bears that can be taken without causing a population decline (Taylor et al., 1987). The flexible quota system, allowing sex-selective hunting, assumes that the sustainable annual harvest of adult females (greater than two years of age) is 1.6% of the estimated population, and that males can be harvested at twice that rate. Within the total annual quota, each community is allocated a maximum number of males and females. If the quota of females killed is exceeded, the total quota for the subsequent year is reduced by the exceeded amount. During the period 1995–1996 to 1999–2000 the average annual harvest of polar bears in Canadian territories, combined with harvest statistics reported in Alaska and Greenland, was 623 animals while the sustainable harvest estimate was 608 (Lunn et al., 2002). Communities and territorial governments developed and jointly signed Local Management Agreements in the mid-1990s that provide background, provide for use of both scientific and traditional knowledge, and provide the procedure for estimating population size and establishing the annual harvest quota.

Progress has also been made in developing co-management for other marine mammals, notably the small whales in the eastern and western Canadian Arctic. Conservation and management of the beluga whale (*Delphinapterus leucas*) in Alaska and the NWT is through the Alaskan and Inuvialuit Beluga Whale Committee, which includes representatives from communities and governments as well as technical advisors (Adams et al., 1993). However, only representatives from beluga hunting communities vote on hunting issues. In the eastern Arctic less progress has been made toward co-management for narwhal (*Monodon monoceros*) partly because of a failure to involve fully the Inuit hunters (Richard and Pike, 1993). Advisory and co-management boards and agreements are not necessarily a guarantee of widespread hunter support (Usher, 1995). Klein et al. (1999) compared caribou management under the Beverly–Qamanirjuaq Caribou

Management Board with management of the Western Arctic Caribou Herd in Alaska through a statewide Board of Game. They concluded that information was not flowing effectively from user representatives on the co-management board to the user communities, thus the users did not feel as involved in management of the caribou as in Alaska where regionally based biologists collecting data for management had more interaction with the users.

How do co-management arrangements help to meet the goals of sustainability in conditions of climate change? Experience with Canadian co-management arrangements demonstrates that these systems can be critical tools for tracking the trends in climate change, reducing human vulnerabilities, and facilitating optimal human adaptation to impacts in single-species management. Trust relations growing from formal co-management arrangements also provide conditions from which innovative ecological monitoring and research involving local/traditional knowledge and science add to the system's capacity to cope with change. In short, a focus on biological aspects of wildlife management should be complemented with institutional considerations to understand their full effectiveness in addressing the possible impacts of climate change.

Co-management is defined both with respect to institutional features of an arrangement (Osherenko, 1988) as well as by outcome of sharing of decision-making authority by local communities of resource users and agencies in the management of common pool resources (Pinkerton, 1989). Power-sharing arrangements can emerge through informal relations between parties (e.g., regional biologists and local hunters), as a result of formal agreements, or, as is most common, from a combination of *de jure* and *de facto* relations. Structures for co-management of wildlife therefore differ from conventional state resource management systems in which decision-making is bureaucratically organized and driven primarily by the principles of scientific management. As well, co-management differs from local control in which a resource user community pursues self-determination, largely independent of external parties. In practice, these arrangements result in considerable latitude in the range of authority and responsibility exercised by resource users (Berkes, 1989).

In the Canadian Arctic, formal co-management has become a common feature of the political landscape either through constitutionally entrenched land-claims agreements or as stand-alone arrangements. Implementation is typically directed through boards of users and agency representatives that are advisory to government ministers, agencies, local communities, and various indigenous governance bodies. In most cases, co-management agreements have been struck to specify community rights to hunting and provide a meaningful role for indigenous subsistence users in management decision-making. In several cases they have proven critical in achieving compliance when facing scarcity of resource stocks (e.g., Peary Caribou (*Rangifer tarandus pearyi*) of Banks Island and co-management system of the Inuvialuit Final Agreement).

What is the significance of co-management to sustainability? Meeting the goals of sustainability requires that resource managers, local communities, and other parties cooperate in resource management. These management functions typically include ecological monitoring and impact assessment, research, communication between parties, policy-making, and enforcement. As a part of this process, there is a need for adequate and integrated knowledge at multiple scales of population regulators, habitat relationships, and potential impacts of human activity, including harvesting, on the population (Berkes, 2002; Berkes and Folke, 1998).

A case study of the Canadian co-management of the Porcupine Caribou Herd, toward sustainability under conditions of climate change, is given in the Appendix.

11.3.2.3. Hunting as a threat to wildlife conservation

Hunting can become a threat to wildlife conservation if population size changes unpredictably in response to environmental perturbations or density dependent changes (unless the population size is closely monitored and hunting is adjusted quickly). Most large mammals in the Arctic are relatively long-lived and thus somewhat resilient to interannual environmental variability that may result in loss of a single age class through breeding failure or heavy mortality of young animals. However, extreme conditions such as icing of vegetation or deep snows restricting access to forage may result in near total mortality across age classes (Miller, 1990) or rarely, regional extirpation of populations or subspecies (Vibe, 1967). Muskoxen are large-bodied grazers capable of using low quality forage during winter and with a predominantly conservative lifestyle. Thus, they are adapted to buffering some of the consequences of variable weather and forage supplies (Adamczewski, 1995; Klein, 1992; Klein and Bay, 1994). Caribou, in their much greater range of latitudinal distribution (muskoxen are rarely found in the boreal forests) are less strongly coupled as a species by feedback loops to their forage (Jefferies et al., 1992). However, their more energetic life style, associated with their morphology and behavior, predisposes them to feeding selectively for high quality forage, necessitating extensive movements and often long seasonal migrations between the barren grounds and the boreal forests (Klein, 1992). Long migrations may be an evolutionary strategy that buffers localized variables in forage quality and availability, which may be weather-related. Icing of vegetation in winter and fires on winter ranges in summer are examples of these weather-related influences on winter forage availability. Caribou are vulnerable to other aspects of weather that affect quality and availability of forage on calving grounds, the level of insect harassment and parasitism, and in the Canadian Arctic Archipelago, freedom of inter-island movement. In the northernmost arctic islands, environmental variability becomes more significant as many processes are near their limits of variability, such as plant growth, which plays a large role in determining herbivore reproduction and survival. Consequently, annual variation in population attributes such as pregnancy rates and calf survival is high. For example, Thomas (1982) documented annual pregnancy rates of between 0 and 80% for Peary caribou and the range in calf production and survival between 1982 and 1998 was 23 to 76 calves per 100 cows for caribou on Banks Island (Larter and Nagy, 1999). The amount of environmental variability may exceed the capability of large mammals to buffer changes and lead to unexpected surges in recruitment or mortality. Rate of population change and size will be more unpredictable and thus hunting will be at more risk of being out of phase with the population trend. Changes in caribou numbers on Banks Island is an example of hunting accelerating a decline likely to have already been underway in response to an environmental change (severe snow winters). Caribou declined from 11 000 in 1972 to perhaps less than 1000 (Nagy et al., 1996; J. Nagy pers. comm., 2001).

North of Banks Island is the range of the Peary caribou, which are only found on Canada's high-arctic islands. Trends in Peary caribou numbers are only available from the western high-arctic islands where numbers have fluctuated within a long-term decline from 26 000 in 1961 to 1000 by 1997 (Gunn et al., 2000). In 1991, the Committee on the Status of Endangered Wildlife in Canada classified caribou on the high-arctic and Banks islands as Endangered based on the steep population declines during the 1970s and 1980s. This was believed to have been caused by climatic extremes – warmer than usual autumn storms causing dense snow and icing, which limit access to forage (Miller, 1990).

Institutional circumstances that may lead to wildlife vulnerability to hunting start with limitations in the ability to detect population declines. Detecting declines in caribou or muskox numbers partly depends on recognizing trends in population size (Graf and Case, 1989; Heard, 1985). The aim is to conduct regular surveys, but high costs and large survey areas have increased survey intervals to the extent that population changes have been missed. For example, the inter-island caribou population of Prince of Wales and Somerset Islands was considered to be relatively stable between 1974 and 1980 (estimated at 5000 caribou in 1980). In the early 1990s, Inuit hunters reported seeing fewer caribou on those two islands, which triggered a survey, but not until 1995. The survey revealed that caribou had declined to less than 100 (Gunn et al., 2000).

Problems with detecting population declines are not just technical. Hunters frequently distrust survey techniques and disbelieve the results, especially when declines in caribou are reported (Klein et al., 1999), but the same may be true for muskoxen and hunted whales (Richard and Pike, 1993). Disbelief stems from historical relationships that have involved poor communication, as well as cultural differences in relying on abstract concepts and numbers as opposed to personal observation. Further differences arise over interpretation of factors causing declines – for example, whether caribou have moved away from the survey area or whether numbers declined because deaths exceeded births (Freeman, 1975; Miller and Gunn, 1978). However, merging information derived from scientific investigation and existing weather records with information gleaned from indigenous hunters is increasingly employed as a tool in monitoring wildlife population response to climate change (Ferguson and Messier, 1997; Kofinas, 2002).

Socio-economic factors can affect the vulnerability of wildlife to hunting. The two territories of NWT and Nunavut have been described as having a "Fourth World" economy (Weissling, 1989) with the indigenous population often forming enclaves within the larger communities that are economically dominated by the North American society. The growing human population in the north, nevertheless, remains heavily dependent on hunting and fishing (Bureau of Statistics, 1996). At present, wage earning provides the cash needed for the purchase and operation of equipment and supplies necessary for hunting and fishing, which have become highly dependent on mechanized transport (Wenzel, 1995) (Fig. 11.4),

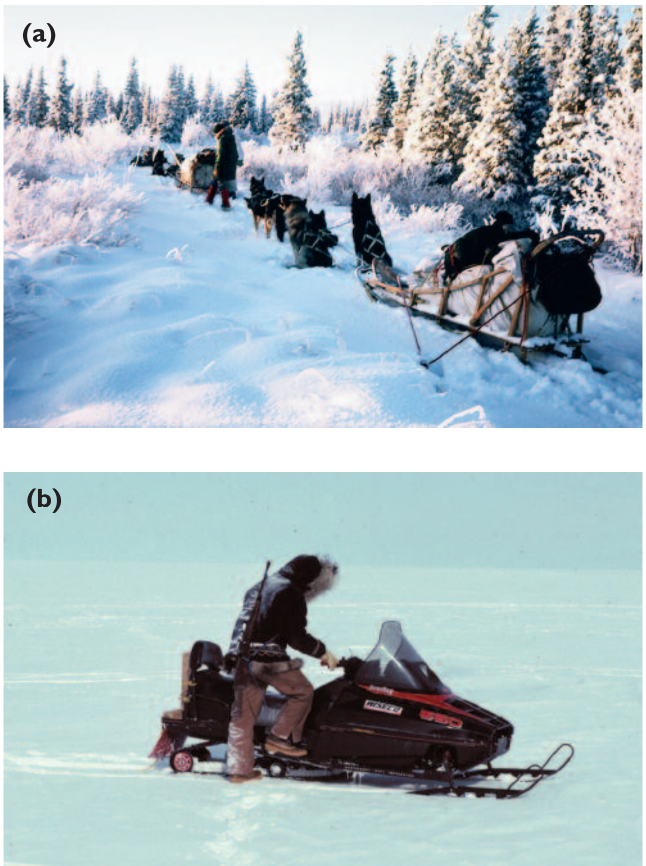

Fig. 11.4. Throughout the Arctic, traditional modes of transport (a) have been largely replaced by mechanized all-terrain vehicles (b) that permit people in many regions of the Arctic to range more widely for subsistence hunting. While this spreads wildlife harvest over greater areas it also requires more extensive survey of the status of wildlife populations as a basis for wildlife management (photo: D.R. Klein).

which in turn creates the need for at least part-time work. However, wage-earning opportunities are relatively limited, shifting the emphasis to commercial use of wildlife and fisheries, but the distinction between subsistence and commercial use is by no means simple. In West Greenland, for example, small-scale sales of minke whales (*Balaenoptera acutorostrata*) and fin whales (*B. physalus*) were considered necessary to maintain cash flow to purchase supplies for subsistence hunting (Caulfield, 1993). But managing for commercial use that is not focused on maximizing profits is inconsistent with systems for management of commercial harvest. Clark (1976) explained the economic rationale for the ease with which commercial harvesting can lead to over-harvesting, especially for long-lived species with low rates of reproduction.

Finally, a mixture of concern and defensiveness exists in response to "outside" (i.e., southern Canada and elsewhere) views or opinions about wildlife harvest and management. In a workshop on future action over the endangered Peary caribou, this was recognized as a serious issue (Gunn et al., 1998), especially in the context of allowing caribou hunting while considering reduction of wolf predation through translocations or other predator control methods. Response to "outside" opinions stems partly from previous experience with some organized animal rights activists and some who see hunting as a threat to animal welfare or conservation. Indigenous hunters, who view their dependency on local resources as sustainable in contrast to the heavy dependency by southern urban dwellers on nonrenewable resources, perceive such urban-based organizations as a threat to their way of life. This view has proven to be the case, for example in the movement against seal hunting that led to the European Common Market's ban on seal skins, which resulted in a substantial loss of income from sealskins in some Inuit communities (Wenzel, 1995).

11.3.2.4. Additional threats to wildlife conservation

The risk that hunting can become unsustainable and cause or contribute to population declines may lie in the unexpected (Holling, 1986). The unexpected ranges from shortcomings in data collection or predictive models, to environmental changes accumulating in unanticipated ways not encompassed by traditional knowledge. Within this context, this includes threats to wildlife from outside the Arctic, such as atmospheric transfer of contaminants and climate change, even if there is uncertainty as to how those threats may unfold in practice. However, management of use of wildlife and associated conservation of wildlife is most difficult in the absence of available methods to monitor both the harvest levels and the status of the populations that are harvested.

Global climate change and the atmospheric transport of contaminants are factors that are already affecting some arctic populations. Global warming in the near future is projected to trigger a cascade of effects (Oechel et al., 1997). Evidence consistent with projections of global climate change in the western Arctic includes Inuvialuit reports of ecological changes such as the appearance of previously unknown birds and insects following trends of warmer weather (IISD, 1999). Along the mainland central arctic coast, Inuit are expressing concerns for the deaths of caribou crossing sea ice as freeze-up is later and break-up earlier than before (Thorpe, 2000).

Sustainability of wildlife for hunting can be affected by influences of climate change on the hunted populations. For example, an increased difficulty in finding winter forage is likely for caribou on the western arctic islands if warmer temperatures bring a greater frequency of freezing rain and deeper snow. Annual snowfall for the western high Arctic increased during the 1990s and the three heaviest snowfall winters coincided with Peary caribou numbers on Bathurst Island dropping from 3000 to an estimated 75 caribou between 1994 and 1997. Muskoxen declined by 80% during the same three winters (Gunn et al., 2000).

Atmospheric and aquatic transport of contaminants has resulted in contaminants reaching detectable levels in arctic wildlife (AMAP, 1997, 2002; Elkin and Bethke, 1995), although effects on population ecology are poorly understood. Although many contaminants that may be detrimental to living organisms are of anthropogenic origin, many derive from natural sources. Persistent organochlorine compounds are carried in the atmosphere, but cadmium is almost entirely from natural sources and mercury is from ocean degassing, natural breakdown, and atmospheric and anthropogenic sources (AMAP, 1997). Bioaccumulation of contaminants can reach levels in marine mammals that pose threats to humans who consume them, especially pregnant and lactating women and their infants (see Chapter 15).

If global warming imposes increased environmental stress on wildlife it is likely to interact with contaminants. For example polar bears, at the top of the marine food chain, accumulate contaminants by eating ringed seals (*Phoca hispida*) and other marine mammals. Relatively high levels of organochlorine compounds and metals are found in polar bears, with relatively strong regional patterns (AMAP, 1997). In female polar bears, although the existing body levels of organochlorine compounds may be sequestered effectively when fat reserves are high, the sequestration away from physiological pathways may be inadequate during a poor feeding season (AMAP, 1997; Polischuk et al., 1994). On western Hudson Bay, there is a trend for female bears to have less fat reserves as sea ice break-up occurs progressively earlier, forcing them ashore where they are required to fast for increasingly longer periods (Stirling et al., 1999). How contaminants in marine systems may change with a changing climate, and what may be the consequences for wildlife and the humans who consume wildlife is not understood, yet an understanding of the nature of the threats posed by contaminants in arctic systems and the processes and pathways involved is critical for the management and conservation of arctic wildlife.

11.3.3. The Fennoscandian North

11.3.3.1. Management and conservation of wildlife under change

In the boreal forest and mountainous areas of northern Fennoscandia the major hunted wildlife species are moose, grouse, dabbling ducks and some diving ducks, and bean geese (*Anser fabalis*). There is increased interest, largely among urban dwellers, to conserve large carnivores. These predatory species are now recovering from high hunting pressures during past decades by farmers and reindeer herders in defense of their livestock. Nevertheless, there have been centuries-long habitat changes in the Fennoscandian Arctic brought about by human activities, including community development and expansion, road and other transportation corridor construction, hydropower development, mining, tourism development, forest clearing, and establishment of military training or test sites (Fig. 11.5). This has resulted in substantial reduction of available habitat for wildlife as well as fragmentation of existing habitats. The consequences for wildlife have been limitations on the freedom of seasonal movements of wildlife, as well as restricted dispersal, and associated genetic exchange, fragmentation of wildlife populations, and lowered overall productivity of the land and waters of northern Fennoscandia for wildlife.

In Norway and Sweden, wolves were completely exterminated during the mid-20th century. Animals from Finland/Russia have recently recolonized the southern, forested part of the peninsula. Bears (*Ursus arctos*) were exterminated in Norway, except for a small population on the border with Russia and Finland. Recovery of bears by dispersing animals from Sweden has occurred in some border areas farther to the south. Decisions have been made that determine areas in which these predators will be tolerated and areas where they will be excluded, largely on the basis of the presence of freely ranging domestic livestock and Saami reindeer. In the exclusion zones in Norway, targeted hunts are held to kill individual large carnivores or groups of them regardless of the status of the species. No wolves have been permitted to reestablish in the Saami reindeer herding areas, which lie north of approximately 63º N.

The climate record and outputs from climate models (Chapter 2 and 4) indicate little change in temperature patterns in northern Fennoscandia in recent decades, in contrast to other parts of the Arctic. Similarly, models projecting future climate trends in the Arctic suggest slow rates of warming in Fennoscandia. An exception is the north coastal region of Norway where models project substantial increases in winter temperature and precipitation. The effects of global warming in the region include ablation of mountain glaciers, altitudinal advances in the treeline, increases in magnitude of defoliating insect outbreaks, and, possibly, a decline in the frequency and magnitude of small mammal population cycles (see Chapter 7). Thus far, there has been little serious research effort focused directly on how changing temperature and precipitation will influence wildlife populations in Fennoscandia.

11.3.3.2. Hunting systems

In general, the moose hunt is based on licenses issued by the regional governments to hunting teams. Each license allocates the number of moose to be harvested from the specific land area for which the license is issued, whether it is private or government owned land. The hunting quota is based on population estimates derived from hunter observations and aerial surveys, including assessment of sex and age composition, but consideration is given to the number of traffic accidents and damage done by moose to forest stands. The timing and length of moose hunting seasons vary within and between countries.

Large carnivore populations are estimated through observations incidental to surveys of other wildlife, local or regional field studies of carnivore species and their prey relationships, and other techniques. Hunting quotas and conservation measures are based on population esti-

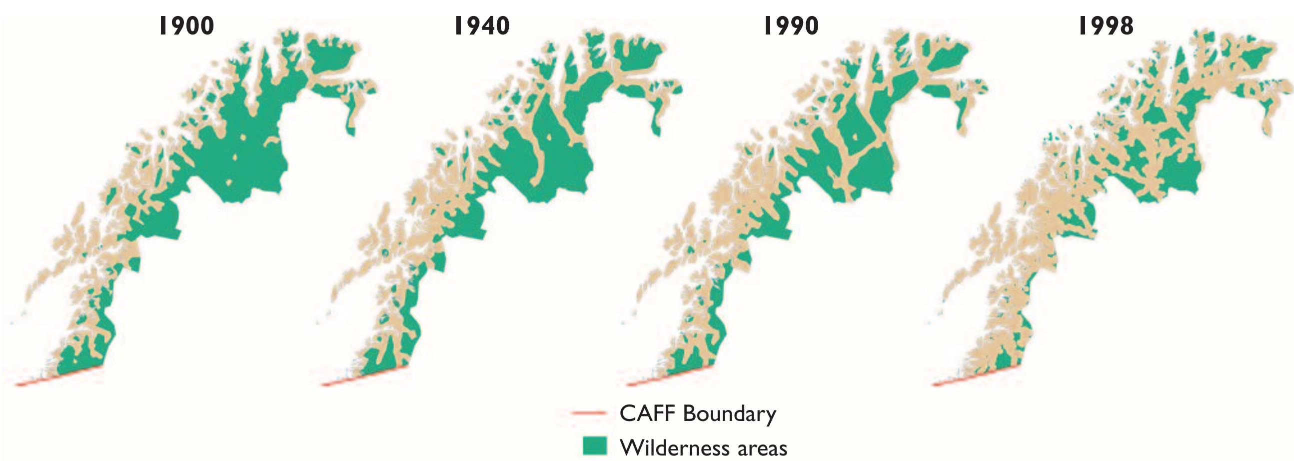

Fig. 11.5. Natural habitat fragmentation in northern Norway is exemplified by the decrease in wilderness areas in Norway north of the CAFF boundary since 1900. Wilderness is defined as an area lying more than five kilometers from roads, railways, and regulated water-courses (Norwegian Mapping Authority as quoted in CAFF, 2001a).

mates, reproductive rates, and levels of predation on reindeer, sheep, and other domestic animals.

The hunting system for ptarmigan and grouse rests primarily on setting of the hunting season dates, which traditionally fall between late August and mid-February. In some areas there is a bag limit, often based on local monitoring programs. Grouse hunting in mountain areas is currently undergoing discussion and the different hunting systems are under evaluation from both the biological and hunters' perspectives.

Wildlife management for hunter harvest of ducks is based primarily on setting the start and duration of the hunting season within the period from late August through late November. Some areas are closed to hunting, including areas around villages.

11.3.3.3. Monitoring systems

In the Fennoscandian countries there is a strong tradition for hunters to report the number of animals killed, and hunters voluntarily assist in wildlife surveys. This is a valuable aid to wildlife management in Finland, Sweden, and Norway and efforts continue to improve the hunter reporting system to ensure greater reliability of the information obtained. Systems for monitoring the population status of moose and large carnivores are among the most highly developed, whereas the least developed system is for ducks, with systems for monitoring ptarmigan and grouse populations intermediate. There is a concern in some areas of the Arctic that these hunter-based systems will be less effective because many young hunters who were born and raised in the rural areas of the North, and having familiarity with the specific wildlife habitats and wildlife of their region, are moving to urban areas to seek employment. Consequently, the number of hunters living close to the land in the Fennoscandian Arctic is decreasing while those from urban centers outside the region are increasing.

11.3.3.4. Flexibility of hunting systems under climate change

With increasing temperatures, in concert with other long-term changes, such as wetland eutrophication, populations of some waterfowl species, for example whistling swans (*Cygnus columbianus*), eider ducks (*Somateria* spp.), and greylag geese (*Anser anser*), are expected to increase in size and to expand their distribution. Consequently, there will be demand for hunting opportunities on these species in areas where today there is no hunting. The procedure for establishing hunting regulations under the present system should be adaptable to allow changes in hunter harvest levels to ensure optimal sustainable harvest through hunting of these waterfowl species. Restrictions on hunting have also allowed recovery of species such as common eider (*Somateria mollissima*) and barnacle goose (*Branta leucopsis*) that nest in the high Arctic, to the point where it may be justified to reconsider opening hunting seasons on them.

Adjustments in moose hunting in response to moose population changes can be achieved through flexibility in establishment of hunting quotas. However, some difficulties can be foreseen. For example, if temperatures during the early part of the hunting season are high there may be difficulties preserving the meat in the field without access to cold storage rooms. This may limit hunting to periods of suitable weather before snow accumulation. This might make it difficult for small hunting teams to fill their quotas. If snow arrives early in the autumn/early winter, access to the hunting grounds may be limited due to difficulties for vehicle travel on logging roads. For the large carnivores, there is similar flexibility in the establishment of hunting quotas.

For grouse and ducks, discussions on hunting regulations mainly concern timing of the hunting season. If the season starts too early the birds are still unfledged and considered too small to hunt. If the hunting season starts too late in the North migratory birds may have already moved south.

Possibilities exist to adjust hunting and the associated management systems in the Fennoscandian North to changes in wildlife populations that may result from the effects of climate change. However, social and economic factors that relate to the various interests in wildlife by local residents and those who come from outside the region also need to be considered in developing wildlife management plans. Management of wildlife in the Fennoscandian Arctic under conditions of a changing climate must be "adaptive" and thus capable of responding to changes in ecosystem dynamics that at times may be unpredictable and therefore unanticipated.

There is a need to establish a comprehensive monitoring program for all wildlife species (moose and some of the large carnivores are currently monitored within each country), with monitoring stations spread out over the Fennoscandian countries, and with coordination of these efforts. There is an urgent need for long-term data as a basis for identifying trends, and a similar need to secure information from remote areas. It is important to develop systems that give "early warning". Such procedures have been in development by the Finnish Game and Fisheries Research Institute that stimulate discussions on changes in hunting systems among and between hunters, wildlife biologists, and regional government wildlife consultants/managers. The resulting adjustment of hunting regulations based on a melding of the interests, concerns, experience, and observations of hunters with the expertise and investigative findings of trained wildlife biologists should provide relatively effective tracking of changes in wildlife populations as a consequence of possible changes in climate.

11.3.4. The Alaskan Arctic

The management system for terrestrial wildlife in Alaska that developed following its admission to statehood in 1959 initially followed the institutional structures adopted by most other states. In both the United States and

Canada, wildlife has been considered by law common property of the people and therefore control of its use, management, and conservation has fallen within the jurisdiction of the state or province within which it occurred. This is in contrast to the system throughout most of Europe where wildlife is the property of the landowner. With the settlement of claims of indigenous peoples in the Canadian North, however, varying levels of responsibility for management of wildlife have been granted to regional indigenous governing authorities. The federal governments of the United States and Canada hold jurisdiction over migratory birds and inter-state or inter-province traffic in harvested wildlife.

In Alaska, a Board of Game, comprising residents of the state appointed by the Governor, establishes regulations governing wildlife harvesting. Regulations established by the board are based on recommendations from professional biologists and managers employed by the Alaska Department of Fish and Game in collaboration with biologists of federal land management agencies, as well as on recommendations from regional citizens advisory groups, and the general public, within the constraints of laws passed by the State Legislature governing wildlife conservation and use. Administrative structure for wildlife management in the State of Alaska mirrors that of other states. Actual wildlife management in Alaska, however, now differs markedly from the other states with similar involvement of the public in resource management decision-making. In Alaska, the federal government, primarily through the U.S. Fish and Wildlife Service, assumes a much greater role in regulation of the harvest of wildlife than in other states. This federal participation in the wildlife regulatory process came about through legislation resulting from settlement of the land claims of the indigenous peoples of Alaska and related legislation by the U.S. Congress (the Alaska Native Claims Settlement Act of 1971 and the Alaska National Interest Lands Conservation Act of 1980). These federal laws mandate that rural residents of Alaska, comprised mostly of indigenous peoples, should receive priority over urban and non-resident hunters in harvesting for subsistence use of the annual surplus of fish and wildlife from federal lands. The state's failure to pass similar subsistence priority legislation, consistent with the state constitution, resulted in the loss of management authority by the state for fish and wildlife on federal lands in Alaska. Since federal lands in national forests, wildlife refuges, national parks, military and other federal reserves, and federal public domain lands constitute 60% of the total land area of Alaska (1.48 million km^2), the federal role in management and conservation of wildlife in Alaska is unique among the states. This federal–state partnership in management of Alaska's fish and wildlife resources has been both controversial and complex and has contributed to political polarization between urban and rural users of fish and wildlife resources (Klein, 2002). However, in most regions of the Alaskan Arctic sufficiently remote from urban centers there is little competition in the harvest of wildlife between the mainly indigenous, rural population and urban hunters, although hunting methods and especially means of transport have changed markedly in recent decades (Fig. 11.4).

In spite of the legal complexities involved in managing Alaska's wildlife, state and federal wildlife biologists and managers increasingly are working together with the users toward maintaining sustainable harvests of wildlife, achieving equitable allocation of the harvest among wildlife users, and improving efficiency of the management process. Biologists and managers with the Alaska Department of Fish and Game, involved with management of caribou of the Western Arctic Herd, Alaska's largest caribou herd estimated to contain 490000 animals in 2003, have been instrumental in establishing a Western Arctic Caribou Herd Working Group whose members represent indigenous and non-indigenous hunters, federal land management agencies, state resource management agencies, and environmental organizations. This working group is viewed as a preliminary step in the process of

Fig. 11.6. Management for sustained harvest and conservation of the large herds of caribou and wild reindeer in North America, Greenland, and Eurasia requires periodic aerial monitoring of the populations. Shown here (a) is a survey flight over the Porcupine Caribou Herd shared by the United States and Canada, involving a photo census over summer concentrations, in conjunction with lower-level flights to obtain sex and age composition counts. Placing collars equipped with radio transmitters on some of the animals (b) enables tracking and locating the herds in their seasonal movements, and assessing mortality rates, fidelity to calving grounds, and other indicators of population status (photos: K. Whitten).

Table 11.3. Status and trends in major land-based wildlife species in the Alaskan Arctic (based on data for 2003 from the Alaska Department of Fish and Game).

	Population status[a] (number per estimate)	Trend	Harvest level[b] (number per year)	Threats
Caribou (by herd)				
Western Arctic	430000	down	22000	weather, coal mining[c]
Porcupine Herd	125000	down	4500	oil development
Central Arctic	27000	stable	1100	oil development
Teshekpuk	27000	stable	3000	oil development
Mulchatna	130000	down	6000	disease[d]
Nushagak	1500	stable	300	no immediate threats
Northern Peninsula	7000	stable	500	disease[d]
Southern Peninsula	3500	up	100	no immediate threats
Adak Island	1500	up	200	no immediate threats
Muskox				
North Slope	1000	stable	40	illegal harvest
Seward Peninsula	800	up	50	no immediate threats
Nunivak Island	500	stable	75	no immediate threats
Nelson Island	230	stable	25	illegal harvest
Moose				
North Slope	750	up	30	disease[e]
Selawik/Kobuk/Noatak	10000	stable	400	no immediate threats
Seward Peninsula	5000	stable	350	no immediate threats
Yukon/Kuskokwim	3000	up	200	illegal harvest[f]
Northern Bristol Bay	3500	up	600	no immediate threats
Alaska Peninsula	5000	stable	300	no immediate threats
Brown bear				
North Slope	2000	up	40	no immediate threats
Selawik/Kobuk/Noatak	3000	up	40	no immediate threats
Seward Peninsula	1250	up	75	illegal harvest[g]
Yukon/Kuskokwim	750	up	25	no immediate threats
Northern Bristol Bay	1500	up	75	no immediate threats
Alaska Peninsula	8500	up	300	no immediate threats
Wolf				
Wolf numbers in coastal areas of Alaska vary widely from year to year because wolves are susceptible to rabies that is periodically enzootic in Arctic foxes. Wolves are probably more common now than at any time over the last 100 years because of the relatively high numbers of moose and caribou that now occur. Wolf densities are higher in the more forested areas where they also can prey on moose. In some local areas (e.g., the North Slope and Seward Peninsula) wolf numbers are below natural levels due to legal and illegal harvest. There are no foreseeable human-related threats to wolves, except on the Seward Peninsula where reindeer herders attempt to exclude them from reindeer grazing areas				
Black bear				
Black bears are abundant in the Kobuk Valley, Yukon Flats, and in most other forested areas, but the Alaskan Arctic is the periphery of black bear range, so they are absent or rare from most arctic areas. Numbers of black bears will probably increase as forest cover expands in northwest Alaska. There are no foreseeable human-related threats to black bears				
Wolverine				
Wolverines are common throughout the Alaskan Arctic, and with the worldwide decline in fur prices, interest in harvesting them has decreased. Wolves commonly kill wolverines and wolverine densities appear to be higher in areas where wolf numbers are low. There are no foreseeable human-related threats to wolverines				
Lynx				
Lynx are cyclic or irruptive in the Alaskan Arctic, and in areas where snowshoe hares become periodically abundant, lynx can become abundant. Lynx are virtually absent from most areas in most years				
Other fur-bearers				
Other common fur-bearers in the Alaskan Arctic are mink, river otter, marten, red fox, and Arctic fox, although all of these except red and Arctic foxes are uncommon on Alaska's North Slope				

[a]Population estimates are based on the most recent census or survey. For some species (e.g., brown bears) data are extrapolated from intensively surveyed areas to larger areas; [b]Estimates adjusted annually based on subsistence harvest surveys. About 85% of the caribou harvest is by local residents. About 50% of moose and brown bears harvested is by local residents. Almost 100% of the harvest of black bears and fur-bearers is by local residents; [c]Most Western Arctic caribou winter in a relatively small area where food could become inaccessible due to unusual and extreme coastal snowstorms and icing. The calving area contains about 50% of the known U.S. coal reserves, but these reserves are unlikely to be developed within the next 50 years; [d]Pneumonia has been prevalent as these caribou herds have declined from high population levels; [e]Moose are recovering from a long-term decline that was possibly related to Brucellosis; [f]Moose, especially in the Kuskokwim River drainage area, are illegally harvested at a rate that prevents population expansion into suitable habitat on the lower reaches of the river; [g]Brown bears are heavily hunted (legally and illegally) in areas with reindeer herding.

establishing a multi-stakeholder system for the Western Arctic Herd in which users play an important role in the management process similar to the Canadian co-management boards for the Beverly and Qamanirjuaq and Porcupine caribou herds (Klein et al., 1999; Thomas and Schaefer, 1991; see also Appendix).

Management of wildlife in the arctic regions of Alaska also differs from wildlife management as traditionally practiced in most of the United States in that natural plant communities that constitute wildlife habitat have undergone little alteration through conversion of the land for agriculture, intensive forest management, industrial development, and urban sprawl. As a consequence, the focus of wildlife management in the Alaskan Arctic by state and federal wildlife biologists has largely been on monitoring structure and harvest levels of the most important hunted and trapped wildlife species rather than on aspects of habitat manipulation or restoration. Population estimates and condition and trend information are collected on caribou, moose, muskoxen, and mountain sheep largely through aerial surveys, facilitated through limited use of radio transmitters placed on some animals in more intensively monitored populations (Fig. 11.6). Similar, but less intensive survey work is also focused on wolves and brown bears as a basis for assessing their potential influence on ungulate populations through predation. This survey information is increasingly being supplemented by harvest information obtained from hunters for development of annual recommendations of harvest levels that are made to the Alaska Board of Game and the Federal Subsistence Division. The status and trends in populations of wild mammals in the arctic regions of Alaska that are hunted and trapped, their harvest levels, and possible threats to their populations are shown in Table 11.3.

Fig. 11.7. The increasing frequency of fires and total area burned in the northern forest zones and in the ecotone between forest and tundra (see Chapter 14), a consequence of climate warming, poses difficult decisions for wildlife managers. Although fire has been a natural feature of the ecology of these plant communities, a reduction in the ratio of older plant communities with high lichen biomass to post-fire early succession stages can be detrimental to caribou and reindeer that feed on the lichens in winter. The shrubs that are characteristic of the post-fire vegetation are also favored by recent climate warming, and provide suitable forage for moose. More intensive efforts at fire suppression may benefit caribou and reindeer, at least in the short term, to the detriment of moose.

Focus on the population dynamics of wildlife is a relatively efficient and cost-effective approach to management of wildlife. However, without inventory and monitoring of vegetation, its quality, and availability as forage within the habitats of large herbivores, knowledge of vegetation changes brought about through climate change, wildfire, or other factors cannot be integrated into the management and conservation of wildlife. The recent and expected continuing increase in area burned by wildfires in the ecotone between the boreal forest and the arctic tundra is of special relevance. This is because much of the lichen-dominated winter range of the large migratory herds of caribou in Alaska lies within this ecotone (Weladji et al., 2002) (Fig. 11.7). Thus the adaptability of management to respond to the effects of climate change is substantially limited.

11.3.4.1. Minimizing impacts of industrial development on wildlife and their habitats

Increasingly, industrial development activities associated with energy and mineral exploration and extraction in the Alaskan Arctic are encroaching on wildlife habitats and threatening wildlife populations through habitat loss, expanded legal and illegal wildlife harvest, and environmental contamination from industrial pollutants entering wildlife food chains. Assessing the magnitude and importance of impacts from existing and proposed industrial development activities in the Arctic is a time-consuming and difficult process under the best of circumstances. This task is rendered even more difficult when the ongoing effects on the environment of accelerated climate change in the Arctic must be factored into the assessment. Although an environmental impact assessment is required under the National Environmental Policy Act of 1969 as a basis for seeking approval for any large-scale federal project "significantly affecting the quality of the human environment", there has been relatively little effort made to undertake follow-up assessments of the actual impacts of projects once they have been approved. The assessments that have been made of the magnitude and ecological significance of threats resulting from specific development projects have been simple, general overviews (Klein, 1973, 1979), or have focused on specific wildlife species (Cameron et al., 2002), or have been limited to a few specific impacts or types of projects (Douglas et al., 2002). Assessment of the consequences of cumulative impacts from multiple interrelated projects taking place over extended periods has only recently been attempted through analysis and synthesis of past studies. The most recent and comprehensive effort in this regard was the *Assessment of the cumulative effects of petroleum development on Alaska's North Slope* that was compiled by a panel of experts appointed through the National Research Council, with a primary focus on the giant Prudhoe Bay and related oil fields (NRC, 2003). Investigative assessment of the environmental consequences of development projects can provide valuable information for the government bodies responsible for weighing the potential consequences of proposed new development projects.

In most of the Alaskan Arctic there is insufficient knowledge of plant and animal distributions on the lands and in the waters, and the ecological relationships existing there, as a basis for carrying out environmental impact assessments in advance of proposed development projects. Short-term studies specifically designed to address postulated impacts on wildlife and their habitats in the absence of an understanding of the complexity of the ecosystem relationships that may be affected are usually inadequate to enable a comprehensive assessment of the environmental impacts that may result from a project. An exception was the proposal to drill for oil in the coastal plain of the Arctic National Wildlife Refuge in northeastern Alaska resulting in the debate before the U.S. Congress in spring 2002. In that case, the background of 20 years of detailed environmental studies of the proposed development area, including mapping of the vegetation and multi-year investigation of the population dynamics and ecosystem relationships of wildlife species, enabled a comprehensive assessment of the expected impacts of the proposed oil development (Douglas et al., 2002). As a consequence, information about the wildlife and other environmental values and the magnitude of the risks to which they would be exposed should oil development be allowed there played a major role in Congress' unwillingness to open the Arctic Refuge to oil development. Assessment of the impacts of proposed industrial development on the ecosystems of the Arctic Refuge was compounded by the difficulty of distinguishing between ecosystem-level effects resulting from climate change influences versus those resulting from the proposed development (Fig. 11.8).

Fig. 11.8. Oil fields in the Alaskan Arctic where displacement of caribou from calving grounds, obstruction of their movements, and herd fracturing has occurred (photos: D.R. Klein). Assessment of the impacts of oil, gas, and mining developments on arctic wildlife is rendered more complex because of the difficulty of differentiating the influences of the changing climate, thus the task of planning to minimize effects of proposed new developments on wildlife and their habitats has become equally complex.

A major obstacle to effective wildlife management in the Arctic in the face of increasing national and global pressures for large-scale energy and mineral extraction is the lack of specific information at the landscape level of wildlife distribution, habitat types and their seasonal use patterns, definition and mapping of critical habitats, and mapping of human land use and related wildlife harvests. An ultimate goal for effective management and conservation of wildlife and wildlife habitats in the Alaskan Arctic, as well as for all regions of the Arctic, is the accumulation of sufficient knowledge of the wildlife and other resources of the lands and waters to enable development of detailed regional land and water use plans. Such plans should employ the use of technology for remote sensing of landscape characteristics and Geographical Information System maps, and include analysis of plant community and soil characteristics, determination of wildlife and fish distribution, identification of critical fish and wildlife habitats, and designation of existing and proposed protected areas. An important part of regional land and water use plans, as the name implies, is mapping of existing patterns of land and water use for subsistence and other human activities, and other physical and biological features of the environment. This documentation of the physical and biological characteristics of the lands and waters of arctic regions would provide a basis for identifying and contrasting changes that may occur in the environment as a consequence of climate change. Its primary value, however, would be in assisting industrial interests in advance planning of development activities in the Arctic to minimize their potential impact on fish and wildlife resources and the users of these resources, and in the evaluation and assessment of proposed industrial developments by local, regional, and national governing bodies prior to their decisions over approval. Details of development of regional land and water use plans and use of environmental impact statements and environmental impact assessments as the basis for land and water use decisions in relation to wildlife management and conservation in northern ecosystems were described by Klein and Magomedova (2003) from which the text in Box 11.4 is abstracted.

Box 11.4. The potential role of regional land and water use planning in wildlife management and conservation in the Arctic

Components of ecosystem planning

- Regional land and water area (aquatic, estuarine, and marine coastal) use plans should be developed by the responsible government units prior to consideration of possible resource extraction developments in all regions of the Arctic.
- The plans should define and map habitat characteristics for wildlife, including identification of critical habitats that may need special protection.
- Traditional and existing patterns of human use of wildlife that are basic to the social, economic, and cultural well-being of the residents of the region should be inventoried, mapped, and included in the plans.
- People, and their use of the land and water resources, should be recognized in the plans as integral components influencing processes of arctic and subarctic ecosystems.

Value and use of the land and water use plan

- Regional land and water use plans available to the responsible governing units, the people residing within the region, and those proposing developments within the region (industry, politicians, and others) clarify limits of acceptability of proposed development activities and structures that may affect wildlife prior to their approval.
- Designation and mapping of critical and sensitive wildlife habitat units that need protection in advance of development proposals simplifies planning and minimizes costly and time-consuming conflicts.

Climate change as a factor in assessing industrial impacts

- Changes in global climate, with pronounced effects in the Arctic and subarctic (see Chapters 7, 8, and 9), add complexity to the task of assigning wildlife-related values and anticipating uses of the land and waters, as well as assessing consequences of development in northern ecosystems.
- Changes in climate globally, and locally within the Arctic (see Chapters 2, 4, and 6), are accelerating social, economic, and cultural changes among human societies within the Arctic, rendering assessment of the consequences of existing and proposed industrial development in the North on human use of wildlife more complex and difficult than in the past.

11.4. Management and conservation of marine mammals and seabirds in the Arctic

Coastal people of the Arctic have, throughout history, depended on marine mammals and seabirds as principal subsistence resources. Seabirds have provided eggs and meat and in some cases skins, and various marine mammal products have been used for meat, clothing, heat, light, tools, toys, and a host of other essential components of day-to-day living (e.g., Donovan, 1982; Kinloch et al., 1992; Pars et al., 2001; Riewe and Gamble, 1988). The great abundance of these animals in the Arctic also attracted attention from the south as early as the 1500s, and large-scale commercial harvests of these animals have been undertaken by a variety of nations within arctic regions – particularly harvests focused on whales and seals. Subsistence harvesting of marine mammals and seabirds currently occurs in most arctic nations. However, hunting intensities differ markedly with community size and density, and the wildlife species present regionally. National and local management regimes are highly varied. Also, the line between commercial and subsistence hunting is not clear, given that some meat as well as skins and tusks from "subsistence" hunts are sold commercially, and sport hunting is conducted on some species within quotas assigned to indigenous communities.

Large-scale commercial harvests of arctic marine mammals are restricted to harp (*Phoca groenlandica*) and hooded (*Cystophora cristata*) seals. But non-indigenous people also commercially harvest a variety of species at smaller scales, such as minke whales in Norwegian waters, belugas in the White Sea, and pilot whales (*Globicephala melaena*) in the Faroe Islands. Sport hunting by non-indigenous peoples is also conducted on grey (*Halichoerus grypus*) and harbour (*Phoca vitulina*) seals and to a lesser extent, ringed and bearded (*Erignathus barbatus*) seals, as well as on a variety of seabird species.

The changes that will occur in hunting patterns due to climate change and the management initiatives that will be necessary to achieve sustainable harvests under new environmental conditions are highly speculative at the moment. Analyses are currently becoming available, such as this assessment, which will help to predict change in the next decades in the Arctic due to climate change (e.g., Newton, 2001; Riedlinger, 1999, 2002; Weller et al., 1999). Some of the most likely changes are:

- modifying the timing and location of harvest activities;
- adjusting the species and quantities harvested; and
- minimizing risk and uncertainty while harvesting in less stable climatic and ice conditions.

The analyses presented in the rest of this section largely serve to document current management regimes in the arctic countries with respect to marine mammals and seabirds. Hopefully, this will serve to highlight where future climate-related impacts might be dealt with via international measures or within the administration of the various arctic countries. It is important to recognize that the marine and terrestrial environments are not distinct from one another. Marine birds and many marine mammals require a land base for some of their life activities, be it nesting sites for birds, maternal dens for polar bears, or haul-out areas used by many marine mammals for resting, breeding, or giving birth. Also, most arctic residents who harvest marine wildlife live in coastal communities at the interface of land and sea.

Several marine mammal and seabird species are managed in part via international agreements or conventions and management issues are also discussed in international fora such as CAFF working groups. For example, polar bear research and management is coordinated internationally via the IUCN Polar Bear Specialist Group. This group was formed following the first international meeting on polar bear conservation, held in Fairbanks, Alaska in 1965, and subsequently led to the development and negotiation of the International Agreement for the Conservation of Polar Bears and their Habitat, which was signed in Oslo, Norway in 1973. The agreement came into effect for a five-year trial period in 1976. It was unanimously confirmed for an indefinite period in January 1981. This agreement stipulates that the contracting parties will conduct national research programs on polar bears related to the conservation and management of the species, will coordinate such research with research carried out by the other parties, will consult with the other parties regarding management of migrating polar bear populations, and will exchange information on research and management and data on bears taken (Wiig et al., 1995). A treaty between the United States and Russia defines a Bilateral Agreement for the Conservation of Polar Bears in the Chukchi/Bering Seas that deals with the management of this specific polar bear stock (USFWS, 1997, 2002a). The North Atlantic Fisheries Organization's Harp and Hooded Seal Working Group performs a similar role regarding coordination of the management of stocks of these two commercially harvested seal species. The North Atlantic Marine Mammal Commission is another international body that promotes cooperation on the conservation, management, study, and sustainable use of marine mammals in the North Atlantic. The International Whaling Commission sets quotas for the commercial harvest of all large cetacean species (currently operating with a total moratorium on commercial harvesting), and also provides a format for discussions regarding small cetaceans. The North Pacific Fur Seal Treaty regulated harvesting of the northern fur seal (*Callorhinus ursinus*) between Japan, Russia, United States, and Great Britain (for Canada) from early in the 1900s until 1985, when the commercial hunt was terminated. A Joint Commission on Conservation and Management of Narwhal and Beluga was established in 1989 to address conservation and management of stocks that migrate between Canadian and Greenland waters. Organizations operating within the Arctic Council, such as CAFF, are playing an increasing role as advisory bodies in conservation and management of sea mammals and seabirds, largely via international working groups. For example, the CAFF Circumpolar Seabird Working Group recently produced the International Murre Conservation Strategy and Action Plan (CAFF, 1996) that identifies management issues related to common (*Uria aalge*) and thick-billed (*U. lomvia*) murres, which experienced significant declines in several circumpolar countries throughout the twentieth century. This group has also developed the International Eider Conservation Strategy (CAFF, 1997). Not all international agreements are legally binding, however, and most legislation regarding wildlife management is undertaken at the national level within the various arctic countries.

The following sections discuss the basic characteristics of management and conservation of marine mammals and seabirds for the main arctic regions. Further information on these regions may be found in Chapter 13.

11.4.1. Russian Arctic

Along with the continental shelf and exclusive economic zone adjacent to its boundaries, the Russian Arctic region accounts for over 30% of the area of the Russian Federation. The Russian continental shelf in the Arctic extends to the greatest distance and has the largest area of any country in the world. The associated shoreline and the area of the basins drained by the Russian rivers flowing into the Arctic Ocean are both huge. The region comprises the Central Arctic zone (roughly north of 80º N) and the Atlantic, Siberian, and Pacific sectors. The Russian Arctic, in particular the Atlantic and Pacific sectors, is characterized by a great diversity of marine ecosystems. Sea ice has an exceptionally important role in the life of marine mammals and birds of the Arctic. The nature of the sea-ice cover and the system of stationary polynyas and ice leads essentially determine the intra-specific structure, dynamics of number of species and populations, and the dates and pathways of their seasonal migrations. Of the marine mammals, the walrus alone is capable of successfully breaking gray ice 10 to 15 cm thick, and adult bowhead whales (*Balaena mysticetus*) break gray-white ice up to 15 to 30 cm thick with their backs. But similar to other marine mammals and birds, walruses and bowhead whales completely depend on the sustainable system of clear water space between pack-ice fields for their northward progress. A number of arctic marine mammal and bird species are circum-polar, and are represented by several populations and even subspecies (e.g., the bowhead whale, walrus, bearded seal, ringed seal, herring gull (*Larus argentatus*), glaucous gull (*L. hyperboreus*), and kittiwake (*Rissa tridactyla*)). They may be fairly isolated geographically as are the Svalbard and Chukchi–Bering sea stocks of the bowhead whale, Atlantic and Pacific subspecies of the walrus, and populations of the same species of seabirds of the Atlantic and Pacific sectors, but occasionally are only separated by massifs of heavy pack ice (the Laptev and Pacific subspecies of the walrus). There are some species that dwell in contiguous regions of Norway and the United States. The Russian Arctic also provides feeding grounds for some southern species, for instance, the Californian gray whales (*Eschrichtius robustus*) and short-tailed shearwaters (*Puffinus tenuirostris*) that nest in southern Australia. A number of species and populations have been classified as rare and protected and accordingly are listed in the Red Data Books of the IUCN and the Russian Federation.

Climate changes have occurred repeatedly in the history of the Arctic. The entire arctic zone exhibited a warming trend during 1961 to 1990; the region from 60º to 140º E (i.e., a substantial part of the Russian Siberian Arctic) showed the greatest warming. Over the last 30 years changes in sea ice have been in conformity with that of the warming trend. The climate, however, in different sectors of the Russian Arctic, both in the past and today, has been variable (AMAP, 1998b; Yablokov, 1996).
The causal connection between global and regional changes in climate, on the one hand, and the number and distribution of arctic marine mammals, on the other, is far more complex than commonly believed. Despite switches between warming and cooling periods, the ranges for the majority of higher vertebrates of the Russian Arctic have been fairly stable over the last millennia. This is confirmed by dating the remains of whales, pinnipeds, and birds (1500 to 2680 years) from ancient coastal villages on the Chukchi Peninsula, located on the main migration routes of the animals, and in their breeding and feeding areas (Dinesman et al., 1996).

Animals of the marine environment are capable of maintaining and even expanding their ranges owing to physiological, biochemical, and behavioral mechanisms for adaptation to changing environmental conditions.
An example is found in the Californian gray whale. Migrating between the feeding areas in the Bering Strait, Chukchi Sea, and East Siberian Sea and the breeding areas in the subtropical lagoons of Mexican California, gray whales annually cover 18 000 to 20 000 km.
This huge migration route covers over 50º of latitude and exposes whales to the effects of constantly changing environmental factors, in particular the strong fluctuations in temperature and photoperiod.

In marine ecosystems, it is primarily the higher vertebrates that have been the most threatened by the rapidly developing direct consequences of human activities, now aggravated by climate change. The increased rate of these impacts frequently exceeds the adaptive capacities of living organisms. Over-harvest of the fish resources of the Barents Sea, primarily capelin (*Mallotus villosus*), resulted in profound rearrangements of the trophic relationships of the entire marine ecosystem, causing massive mortality of marine colonial birds and harp seals in the late 1980s. In 1988, on the southern island of Novaya Zemlya, fish-eating marine birds switched to a zooplankton diet (L.S. Bogoslovskaya pers. obs., 2003).

Throughout the 1990s the economic development activities that caused these detrimental processes increased many times due primarily to sharp increases in oil and gas production in the coastal regions and increased ship transit through polynyas and stationary ice leads, which are vital for marine mammals and birds in the high latitudes. This was most pronounced in the Atlantic sector. Pollutants associated with these activities and those from industrial activities on land that reach the sea through the major river systems flowing into the arctic seas have been found at all trophic levels of the biota, frequently causing morbidity and mortality of marine animals.
In the early 1990s maps were compiled indicating levels of pollution by heavy metals, organochlorine compounds, petroleum products, and phenols in surface waters and bottom sediments of the seas of the Russian Arctic (Melnikov et al., 1994).

In the former Soviet Union, the Arctic was never legally defined geographically. Depending on current needs of the state, the southern border of the Arctic was delineated to serve immediate and short-term interests. The Soviet government apparently intended to extend the region's northern boundary to the North Pole but never made a full-scale claim over such a Soviet Arctic sector. The Soviet Arctic was always classified as a closed frontier zone and administrated accordingly. All services, including those purely civil, were to a large extent included in the classified status. This also applied to environmental monitoring of terrestrial and marine areas, and particularly to plant and wildlife species. In present-day Russia this situation has, nevertheless, deteriorated. The limited system of arctic environment monitoring, developed in Soviet times, was virtually discontinued. For lack of funds, no new national parks or coastal and marine reserves and sanctuaries were established through federal, regional, or local jurisdictions. Existing protected areas, for lack of financing, have had funding reduced or eliminated for research as well as for protection from detrimental human activities (Yablokov, 1996). The network of specialized marine sanctuaries, reserves, and parks considered necessary for protection of arctic cetaceans and pinnipeds has not had any significant development.

The Parliament (Federal Assembly) of the Russian Federation has so far enacted no law, amendment, or supplement to the current laws on the protection of the arctic environment. Moreover, the term "Arctic" is absent from the federal legislation. In some instances the term "Extreme North" is used, but this term is not used in international documents. No national arctic doctrine has been elaborated to reflect the many diverse interests of the Russian society in the Arctic, including protection of polar marine ecosystems. Thus, the Russian situation is unique. Federal governing bodies have signed a number of important international acts and bilateral agreements on the environment and sustainable development of the Arctic, but national legislation or statutory framework for management and protection of the arctic ecosystems has not been developed. At present no adequate legal framework exists for management and protection of the marine ecosystems of the Arctic and the associated species, subspecies, and populations of birds and mammals. There are, however, international documents, including ratified conventions and agreement on a number of species.

Russia is a member of the IUCN Polar Bear Specialist Group and operates under a 1973 International Polar Bear Agreement. In fact, polar bear hunting was banned in the former Soviet Union in 1956 and until very recently only problem polar bears could be killed (Belikov, 1993). However, the level of protection has diminished recently due to economic and political changes that make nature conservation and control of the use of the environment ineffective, and an increased interest by Russian people in using polar bears as a resource has been expressed. An agreement signed by the Government of the United States and the Russian Federation on October 16, 2000, recognized the need of indigenous people to harvest polar bears for subsistence purposes. It includes provisions for developing sustainable harvest limits, allocation of the harvest between jurisdictions, and the need for compliance and enforcement. Half the harvest limit, which is yet to be decided, will be allotted to each country. The agreement reiterates requirements of the multi-lateral polar bear agreement and restricts harvesting of denning females, females with cubs, or cubs less than one year old, and prohibits use of aircraft, large motorized vessels, snares, or poison. The agreement does not allow hunting for commercial purposes or commercial uses of polar bears

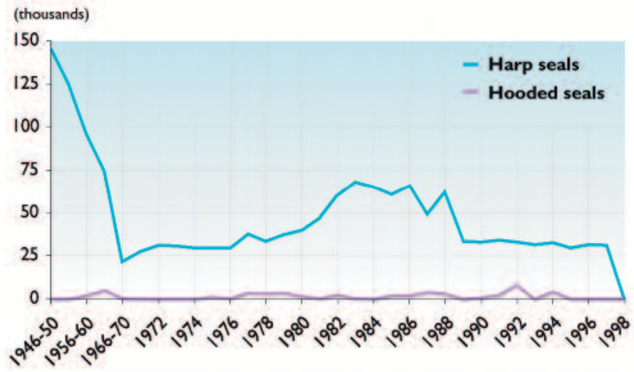

Fig. 11.9. Commercial harvest of harp and hooded seals by Russian vessels since the mid-1940s (East and West Ice combined).

or their parts. It commits the partners to the conservation of ecosystems and important habitats, with a focus on conserving specific polar bear habitats such as feeding, congregating, and denning areas. Mechanisms to coordinate management programs with the Chukotka government and with the Chukotka indigenous organizations are currently being determined. The agreement is currently undergoing procedural handling by the U.S. Congress and required legislative steps in Russia are being determined (USFWS, 1997, 2002a).

Other marine mammal harvests within Russia are managed on the basis of Total Allowable Catches (TACs) that are assigned by species and geographical region (Table 11.4). Catches of commercial species such as harp and hooded seals have remained constant over the last few decades (Fig. 11.9). However, reporting of harvest statistics and enforcement of TACs is difficult to manage in outlying areas given Russia's current economic and administrative difficulties and the status of populations and their harvests is in reality largely unknown.

Indigenous people in Russia have collected seabirds and their eggs since ancient times. Non-indigenous people have also harvested seabirds in coastal areas since the colonization of northwest and northeast Russia more than two centuries ago (Golovkin, 2001). In the Barents Sea

Table 11.4. Total allowable catches of marine mammals in Russia for 2002 (Government of the Russian Federation, 2001).

	Western Bering Sea	Eastern Kamchatka		Sea of Okhotsk			Caspian Sea	Barents Sea	White Sea
		Karaginskaya	Petropavlovsk-Komandorskaya	Northern Sea of Okhotsk	Western Kamchatskaya	Eastern Sakhalinskaya			
White whale	300			400	100	200		500	50
Killer whale						5			
Northern fur seal			3400			1800			
Walrus	3000								
Ringed seal	5900	600		18500	6000	3500		1500	1100
Ribbon seal	5800	200		9000	500	5500			
Bearded seal	4000			4800	1900	700		250	100
Caspian seal							500		

Note: Total Allowable Catch of white whales, killer whales and walruses are given for subsistence needs of small peoples of the North and Far East and for scientific and cultural-educational purposes.

region tens of thousands of eggs were collected annually from the middle of the 19th century until the beginning of the 20th. During the 1920s and early 1930s the number of eggs collected increased dramatically. For example, at Besymyannaya Bar, Novaya Zemlya 342 500 murre eggs were collected and more than 12 000 adult birds were killed in the 1933 season alone (Golovkin, 2001). The need for conservation was recognized at the time, and several state reserves were established in the late 1930s where egg collecting and bird harvesting were prohibited. In the Commander Islands, near Kamchatka in the southern Bering Sea, seabird exploitation began with the first Russian expeditions to the area. Pallas's cormorant (*Phalacrocorax perspicillatus*) was harvested heavily and this is thought to have contributed to the extinction of this species. In the 19th century the Commander Islands were settled by Russians and Aleuts. These established residents began to harvest eggs and birds in the tens of thousands annually. Their preferred species were northern fulmars (*Fulmarus glacialis*), pelagic cormorants (*P. pelagicus*), thick-billed murres, horned puffins (*Fratercula corniculata*), tufted puffins (*F. cirrhata*), and glaucous-winged gulls (*Larus glaucescens*). In Kamchatka, local people collected 4000 to 5000 glaucous-winged and black-headed (*L. ridibundus*) gull eggs annually in the past, but the collection is thought to be negligible currently.

Traditional patterns of harvesting seabird eggs continued despite national hunting regulations prohibiting harvest of eggs of all bird species everywhere in Russia. In the Murmansk region however, local hunting regulations permit hunting of alcids (auks, puffins, guillemots, etc.) in autumn and winter (Golovkin, 2001). All four eider species are protected along the entire coast of Russia. It is known that some illegal harvesting takes place due to a general lack of enforcement. In the Barents Sea region it is thought that thousands of eggs are collected annually (Golovkin, 2001). It is known that 2000 glaucous-winged gull eggs were collected in 1999 and again in 2001 from Toporkov Island, where the largest colony of the species exists among the Commander Islands (CAFF, 2001b). Illegal egg collecting is also known to be a common activity among inhabitants of villages and crews of visiting vessels in the northern Sea of Okhotsk and human influences on easily accessible colonies of common eiders has increasingly been evident on the northern coast of the Koryak Highlands, Chukotka. The need to improve seabird management plans, conservation laws, and hunting regulations is recognized (Golovkin, 2001).

The scientific community of Russia, the indigenous minorities of the North, and the non-governmental environmental organizations have been campaigning for a refinement of the legislative framework regarding the Arctic. There are, however, few examples of fruitful cooperation between governmental bodies and indigenous and local organizations for management and protection of the natural environment of the Arctic. One positive example, however, concerns the 25-year monitoring of marine mammals and their harvest by the indigenous Inuit and Chukchi peoples of the Chukchi Peninsula, associated with Russian participation in the International Whaling Commission. These activities have been possible through the active role and support of agencies of the US government responsible for marine mammal and bird conservation and management, and indigenous peoples' corporations of Alaska.

11.4.2. Canadian Arctic

Polar bear harvesting in Canada is undertaken in accordance with the 1973 International Polar Bear Agreement. Between 500 and 600 polar bears are taken annually in Canada by Inuit and Amerindian hunters under a system of annual quotas that is reviewed annually in Nunavut, the NWT, Yukon Territory, Ontario, Manitoba, Quebec, and Newfoundland/Labrador. Within the quota assigned to each coastal village in the NWT and Nunavut, hunters are allowed to allocate a number of hunting tags to non-resident sport hunters, who are guided by local Inuit hunters. Sport hunting and the sale of skins are important sources of cash income for small settlements in northern Canada. The annual economic value of the polar bear hunt is about one million Canadian dollars (CWS/CWF, 2002). The Canadian Wildlife Service represents Canada in the International Polar Bear Working Group.

Seal and whale management falls within the jurisdiction of the Department of Fisheries and Oceans (DFO) at the federal level. Harp and hooded seals are commercially hunted using a quota system in Canadian waters and shared stocks with Greenland involve some co-management. For 2002, the TAC for harp seals was 275 000 and for the hooded seal 10 000 (DFO, 2002a). Sale, trade, or barter of harp seal white-coat pups or hooded seal blue-backs (pups) is prohibited under Canada's Marine Mammal Regulations. The use of vessels over 65 ft (19.8 m) in length is also prohibited. The actual number of animals harvested varies from year to year depending on sea-ice conditions, market prices, or subsidy systems (Fig. 11.10), although the actual harvest quota has remained constant in recent years. Some subsistence hunting of harp and hooded seals takes place in northern regions, but this hunt only numbers a few thousand animals. Grey seals are harvested in a small, traditional commercial hunt in an area off the

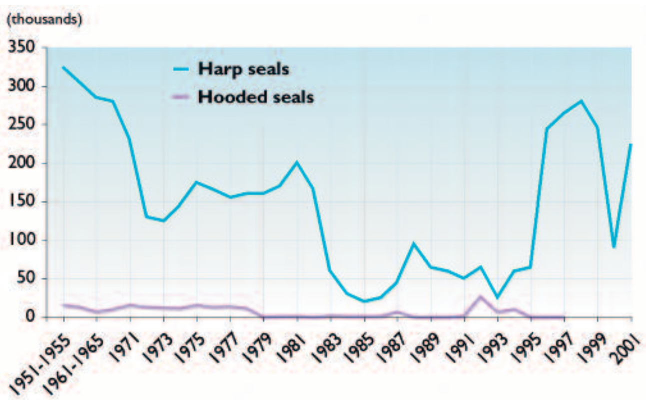

Fig. 11.10. Commercial catches of harp and hooded seals in Canadian waters since 1950 (from seal catch data for Canada, Norway, and Russia collated at the North Atlantic Marine Mammal Commission, Polar Environmental Center, Tromsø, Norway).

Magdalen Islands and at a few locations in the Maritimes. The numbers taken are small and thus a TAC has not been established. Ringed seals and bearded seals are taken in subsistence harvests in Labrador and throughout the Canadian Arctic, but figures are not available regarding harvest levels. Ringed seals are by far the most important arctic seal for human consumption and utilization in the Canadian Arctic. The Nunavut Wildlife Management Board has conducted a five-year harvest study on all species of seals and the resulting report is available via their website (www.nwmb.com/english). Subsistence hunting of arctic seals is not regulated.

Commercial harvesting of walrus was banned in Canada in 1931. All hunting currently conducted is indigenous subsistence hunting. Walrus harvest regulations are undergoing changes with the establishment of Nunavut but currently, residents of Coral Harbour, Sanikilqaq, Arctic Bay, and Clyde River have DFO-established quotas, and all other Inuk residents are permitted to hunt up to four walrus per year. Similar to the situation for polar bears, communities can set some of their quota aside for sport hunting by non-indigenous people (McCluskey, 1999). Four Atlantic walrus stocks occur in the eastern Canadian Arctic: Foxe Basin, Southern and Eastern Hudson Bay, Northern Hudson Bay–Hudson Strait–Southern Baffin Island–Northern Labrador, and the North Water (Baffin Bay–Eastern Canadian Arctic). The status of three of the four is classified as poorly known and the fourth is “fair”. In the latter case, the stock is currently being harvested at a removal rate of 300 animals, which may exceed sustainable yield (Born et al., 1995). There is a similar concern regarding the North Water stock and the Southern and Eastern Hudson Bay stocks. The final stock is so poorly known that it is not reasonable to attempt to determine whether current harvest levels are sustainable or not.

Canada discontinued commercial whaling in 1972. However, whaling has been important to Inuit in the Arctic since prehistoric times and Arctic Inuit currently hunt about 700 beluga and about 300 narwhal annually in Canada. There is concern for the conservation of several beluga stocks in eastern Canada, while those in the west are harvested well within sustainable yields (DFO, 2000, 2002b). The St. Lawrence River population is endangered, although it has been completely protected from hunting since 1979. Also, populations in Southeast Baffin Island–Cumberland Sound and Ungava Bay are endangered, and the Eastern Hudson Bay population is threatened. The Eastern High Arctic/Baffin Bay population is classified as a special concern. Subsistence hunting of belugas in some parts of the Arctic is a concern because of its potential to cause continued decline or lack of recovery of depleted populations (DFO, 2002b). Narwhal are hunted in Hudson Bay and Baffin Bay under a quota system in 19 communities (DFO, 1998a,b). Baffin Bay narwhals summer in waters that include areas in northwestern Greenland and thus are a shared stock. Recent reviews of these stocks have been performed in consideration of new management options for this species.

Hunting of bowhead whales has recently been resumed in both the eastern and western Canadian Arctic following the settlement of land claim agreements, based on the traditional cultural value of these hunts (DFO, 1999). Both bowhead whale populations are classified as endangered (COSEWIC, 2002; DFO, 1999). Harvesting of these populations violates the intent of the International Whaling Commission (Finley, 2001), although Canada is not a member of this whaling regime. Subsistence whaling is currently managed under three separate land claim agreements – the James Bay Northern Quebec agreement, the Inuvialuit Final Agreement, and the Nunavut Land Claims Agreement – in the Canadian North.

Seabird harvesting in Canada dates back thousands of years to early colonization by indigenous peoples. Historically, seabirds were an important component of the subsistence lifestyle for coastal peoples, but today seabird harvesting for birds and eggs is much less widespread, although improved hunting technologies have tended to increase harvests on species such as murres (Chardine, 2001). Regulation of seabird harvesting (with the exception of cormorants and eiders) is done under the Migratory Bird Convention Act of 1917 that protects them year-round from hunting. Indigenous people in Canada are exempt from this restriction and can at any time take various auk species and scoters (*Melanitta* spp.) for human food and clothing. Eiders are hunted as game birds by both indigenous and non-indigenous people in a controlled annual hunt. Seabird egg collecting is not permitted under the general terms of the convention, but indigenous people are allowed to take auk eggs (Chardine, 2001).

Common eiders, thick-billed murre, and black guillemot (*Cepphus grylle*) are the most commonly harvested seabird species in arctic Canada, and are utilized by indigenous people wherever they are available (Chardine, 2001). There is no comprehensive monitoring of seabird harvests in Canada, but the total annual seabird take in the Arctic is thought to number about 25 000 individuals, about half of which are common eiders. Egg collecting is not as widespread as bird hunting, and has usually involved ground nesting species such as common eiders, Arctic terns (*Sterna paradisaea*), and gulls, which is technically illegal, as well as little auks (*Alle alle*). It is thought that some few thousand eggs are collected annually (Chardine, 2001). The most intense consumptive use of seabirds in Canada occurs in Newfoundland and Labrador, where thick-billed and common murres are harvested based on a set hunting season and bag limits. In the past, hunting levels were extreme, and recently enacted legislation is attempting to bring the harvest to sustainable levels. Currently, 200 000 to 300 000 murres are shot in the Newfoundland/Labrador hunt and approximately 20 000 common eiders are taken in Atlantic Canada. Atlantic puffin (*Fratercula arctica*), dovekie (little auk), razorbills (*Alca torda*), and black guillemots are legally hunted in Labrador. Illegal harvesting of other species such as shearwaters (*Puffinus* spp.), gulls, and terns is also known to occur (Chardine, 2001). Seabird harvests on the north shore of the St. Lawrence River in Quebec were considered large enough to have reduced seabird populations, but a recent education program is thought to have reduced local hunting pressure to a level where population recovery is expected (Blanchard, 1994). One of the primary needs for improving the management of seabird harvests in Canada is to improve knowledge regarding the current level of seabird harvesting, particularly in regions where harvest is thought to be substantial but little information exists (Chardine, 2001). The Canadian Wildlife Service, in cooperation with various indigenous wildlife management boards, co-manages seabirds in the Arctic.

11.4.3. Fennoscandian North

Marine mammal harvesting has been a tradition in Norway, Iceland, the Faroe Islands, and Greenland for centuries. Norway and Greenland, the only Fennoscandian countries that have polar bears, are both signing members of the International Agreement on the Conservation of Polar Bears (IACPB). Denmark signed the original agreement, but Greenland Home Rule took over legal responsibility for management of renewable resources, including polar bears, in 1979. Polar bears are completely protected in Svalbard (Wiig, 1995). Only bears causing undue risk to human property or life have been shot since the closure of the harvest some decades ago; these cases are dealt with under the authority of the Governor of Svalbard, which acts under the Norwegian Ministry of the Environment and the Ministry of Justice. Polar bears are legally harvested in Greenland. Full-time, licensed hunters have taken an average of 150 bears per year in Greenland in recent decades in accordance with most international recommendations for harvesting, although some local rules in some regions do not entirely conform to the IACPB (Born, 1993). The Greenland Institute of Natural Resources, which has been operating since 1995, is concerned that polar bears may require increased protection in Greenland.

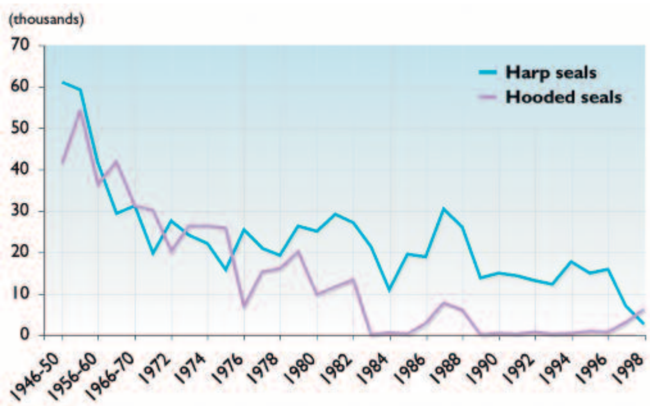

Fig. 11.11. Commercial catches of harp and hooded seals in the West Ice by Norwegian vessels since the mid-1940s (from seal catch data for Canada, Norway, and Russia collated at the North Atlantic Marine Mammal Commission, Polar Environmental Center, Tromsø, Norway).

In Norway, harp seals and hooded seals are commercially harvested, based on government-set quotas. The harp and hooded seal harvests are managed in agreement with the North Atlantic Fisheries Organisation. Current harvest levels are low compared to takes early in the 20th century (Fig. 11.11), and are set within sustainable limits. Ringed seals and bearded seals can be freely harvested in Svalbard outside their respective breeding seasons, but actual takes are very low. Harbour seals on Svalbard are Red Listed, and are completely protected. Coastal seals along the northern coast of Norway, which include grey and harbour seals as well as small numbers of ringed and bearded seals, are hunted through species-based quotas and licensing of individual hunters. Grey seals and harbour (common) seals are harvested in Iceland; catches of these two species have dropped gradually over recent decades and currently about 1000 harbour seals and a few hundred grey seals are caught annually. In Greenland, about 170 000 seals are taken annually, mainly harp and ringed seals. They are an important source of traditional food, and about 100 000 skins are sold annually to the tannery in Nuuk, Greenland (Jessen, 2001). There are few national regulations in Greenland regarding seal hunting; there are four Executive Orders, two related to catch reporting, one banning exportation of skins from pups, and the fourth is a regulation on harbour seal hunting in spring. There is concern that harbour seals may be in threatened status in Greenland (Jessen, 2001). With the exception of harbour seals, Greenland's seal stocks are plentiful.

Walruses were commercially harvested in Svalbard historically, to the brink of extirpation, but are now totally protected and are recovering (Born et al., 1995). The walrus population that winters off central West Greenland is harvested at a level that is thought to exceed sustainable yield (Born et al., 1995). Approximately 65 walruses are taken annually from this area where only about 500 animals remain. The same is true of the North Water stock that winters along the west coast of Greenland as far south as Disko Island. At this location about 375 walruses are taken annually from a group that only numbers a few thousand. In East Greenland, the small harvests focus mainly on adult males, and are thought to be within the replacement yield.

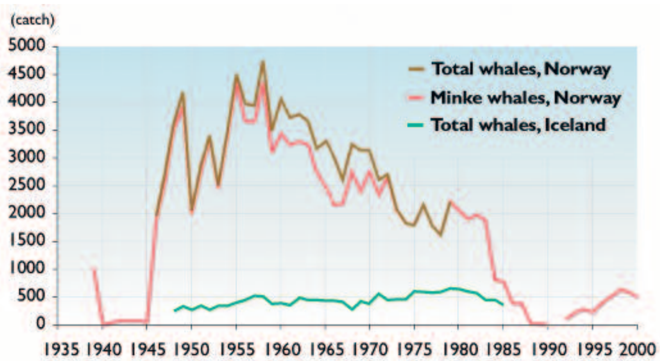

Fig. 11.12. Commercial catches of cetaceans in Norway and Iceland since 1939 (whale harvest data for Iceland from the Marine Research Institute, Reykjavik, Iceland; and for Norway from Statistisk Sentralbyrå, Oslo, Norway).

Whaling has been a traditional undertaking in Norway for centuries. However, cetaceans, large and small, with the exception of minke whales, are completely protected in Norwegian waters currently. Approximately 600 minke whales have been taken annually in recent years in the commercial hunt in Norwegian waters (Fig. 11.12). Management of this harvest is the responsibility of the Ministry of Fisheries, as is the case for all commercial marine mammal hunting in Norway. The harvest quota for minke whales is set by the Norwegian Government. This harvest is considered sustainable, and was sanctioned by the Scientific Advisory Board of the International Whaling Commission, but is in violation of the International Whaling Commission's total ban on commercial whaling. Norway, however, has entered a reservation against the moratorium, so its harvest is not strictly speaking a violation of International Whaling Commission decisions. Some poaching of harbour porpoise (*Phocoena phocoena*) is thought to take place along the Finnmark coast, but the level of this harvest is unknown. Although Iceland is technically not currently whaling commercially (Fig. 11.12), it was announced in August 2003 that Iceland would begin culling minke whales for "scientific purposes"; Iceland has been importing whale meat from the Norwegian minke whale harvest. In the Faroe Islands whales are harvested for local meat consumption. The majority of the harvest is pilot whales. The hunt has ranged from a few hundred animals to a few thousand in recent years. Other species are also taken, although less frequently, including humpback whales (*Megaptera novaeangliae*), bottlenose dolphins (*Tursiops truncatus*), harbour porpoises, and white-sided dolphins (*Lagenorhynchus acutus*). Indigenous people in Greenland continue their long tradition of subsistence whaling. The harvests currently focus mainly on white whales and narwhal coastally, but fin and minke whales are also taken, as well as pilot whales sporadically, and killer (*Orcinus orca*) and humpback whales have been taken on occasion. The fin and minke whale catches are sanctioned by the International Whaling Commission (2002), within the agreements for indigenous subsistence whaling. West Greenland is permitted an annual catch of 19 fin whales. West Greenland has an annual quota of 175 minke whales and East Greenland can take up to 12 of this species annually (until 2006). The Institute of Natural Resources, of the Home Rule Government, has documented that beluga have declined due to overexploitation in Greenland, and suggests that this species needs increased protection along with the narwhal and harbour porpoise (Fig. 11.13). The Greenland Home Rule Government is currently revising the management plan and hunting regulations for small cetaceans (K. Mathiasen pers. comm., 2004).

Fig. 11.13. Harvests of some seabird and marine mammal species for sale in country food markets (as shown here at Nuuk, Greenland in 1991) may exceed the sustainability of their populations, justifying setting of harvest quotas and establishment of protected areas (photo: D.R. Klein).

The cultural traditions for seabird harvesting in the Fennoscandian North are varied. In Finland there is no tradition for hunting alcids. Species such as eiders, oldsquaw (*Clangula hyemalis*), common merganser (*Mergus merganser*), and red-breasted mergansers (*M. serrator*), are hunted by set seasonal open and closing dates. Egging has been forbidden since 1962, with the exception of the autonomous region of the Åland Islands in the southwest archipelago (Hario, 2001). This region has its own hunting act that regulates the take of seabirds. Present harvests in Finland are thought to be sustainable; selling harvested birds is not allowed. In Iceland, there is a long tradition of harvesting seabirds, including northern fulmars, Arctic terns, black-headed gulls, great (*Larus marinus*) and lesser (*L. fuscus*) black-backed gulls, herring gulls, glaucous gulls, eiders, Atlantic puffins, common and thick-billed murres, razorbills, and black-legged kittiwakes (Petersen, 2001). Great cormorants (*Phalacrocorax carbo*), shags (*P. aristotelis*), black guillemots, and northern gannets (*Sula bassanus*) are also harvested but to a lesser degree, and eggs of gulls, terns, and sometimes eiders are also collected, although there are no records of egg numbers (Petersen, 2001). Eider down is also utilized. Seabird meat is sold in Iceland, and there has been increasing market demand for this during the last 10 to 15 years as a specialty item for tourists. The Ministry of the Environment supervises the Act on Conservation, Protection, and Hunting of Wild Birds and Land Mammals in Iceland. Seasons are set for shooting individual bird species, but the periods for egg collecting and catching of young are not specified. Three gull species that are classified as pests can be killed year-round. Information on current population sizes and the effects of harvesting, as well as more information on egg collecting, is needed to improve managements of seabird harvests in Iceland (Petersen, 2001).

The Faroe Islands have a long tradition of seabird harvesting that continues today. The two dominant target species are northern fulmars and puffins. Norway also has a long tradition of harvesting marine birds. Down collecting and harvesting eggs, adult birds, and chicks have been important subsistence and commercial activities for rural residents of coastal northern Norway (Bakken and Anker-Nilssen, 2001). Significant hunting and collecting have also taken place at Bjørnøya and Svalbard until recent decades. Currently, hunting is only permitted on a small number of marine birds (Svalbard – northern fulmar, thick-billed murre, black guillemot, and glaucous gull; mainland – great cormorant and shag, greylag goose, oldsquaw and red-breasted merganser, black-headed gull, common gull, herring gull, great black-backed gull, and black-legged kittiwake) during set

Table 11.5. The status of marine birds breeding in the Barents Sea region (Anker-Nilssen et al., 2000).

	National Red List[a]		Bern Convention[b]	Bonn Convention[c]
	Norway	Russia		
Great northern diver (*Gavia immer*)	R		II	II
Northern fulmar (*Fulmarus glacialis*)			III	
European storm petrel (*Hydrobates pelagicus*)			II	
Leach's storm-petrel (*Oceanodroma leucorhoa*)			II	
Northern gannet (*Morus bassanus*)			III	
Great cormorant (*Phalacrocorax carbo*)			III	
European shag (*Phalacrocorax aristotelis*)		R	III	
Greylag goose (*Anser anser*)			III	II
Barnacle goose (*Branta leucopsis*)			II	II
Brent goose (*Branta bernicla*)	V	R	III	II
Common eider (*Somateria mollissima*)			III	II
King eider (*Somateria spectabilis*)			II	II
Steller eider (*Polysticta stelleri*)			II	I/II
Long-tailed duck (*Clangula hyemalis*)	DM		III	II
Black scoter (*Melanitta nigra*)	DM		III	II
Velvet scoter (*Melanitta fusca*)	DM		III	II
Red-breasted merganser (*Mergus serrator*)			III	II
Eurasian oystercatcher (*Haematopus ostralegus*)			III	
Purple sandpiper (*Calidris maritima*)			II	II
Ruddy turnstone (*Arenaria interpres*)	R		II	II
Red-necked phalarope (*Phalaropus lobatus*)			II	II
Grey phalarope (*Phalaropus fulicarius*)	V		II	II
Arctic skua (*Stercorarius parasiticus*)			III	
Great skua (*Catharacta skua*)			III	
Sabine's gull (*Xema sabini*)	R		II	
Black-headed gull (*Larus ridibundus*)			III	
Mew gull (*Larus canus*)			III	
Lesser black-backed gull (*Larus fuscus*)	E[d]			
Herring gull (*Larus argentatus*)				
Glaucous gull (*Larus hyperboreus*)			III	
Great black-backed gull (*Larus marinus*)				
Black-legged kittiwake (*Rissa tridactyla*)			III	
Ivory gull (*Pagophila eburnea*)	DM	R	II	
Common tern (*Sterna hirundo*)			II	II
Arctic tern (*Sterna paradisaea*)			III	II
Common murre (*Uria aalge*)	V		III	
Thick billed murre (*Uria lomvia*)			III	
Razorbill (*Alca torda*)	R		III	
Black guillemot (*Cepphus grylle*)	DM		III	
Little auk (*Alle alle*)			III	
Atlantic puffin (*Fratercula arctica*)	DC		III	

[a]Categories: E (Endangered), V (Vulnerable), R (Rare), DC (Declining, care demanding), DM (Declining, monitor species); [b]II should be protected against all harvesting, III should not be exploited in a way that may threaten their populations; [c] I includes species that are considered threatened by extinction. II are not threatened by extinction, but international co-operation is needed to ensure protection; [d] Red List for Svalbard only.

seasons. Egg collecting is permitted from herring gulls, great black-backed gulls, common gulls, and black-legged kittiwakes early in the laying season. Eider eggs are collected only in areas where construction of nest shelters for eiders is traditional. Harvests within Norway are considered within sustainable limits, but there is concern that some seabird stocks shared with Russia and Greenland may currently be excessively harvested (Table 11.5; Bakken and Anker-Nilssen, 2001).

Seabird harvesting in Greenland has a long history and continues to have a key role in Greenland's subsistence hunting. Murres and eiders are the most heavily harvested species, but others such as dovekies and kittiwakes are also harvested frequently in some regions of the country (Fig. 11.13). There are acknowledged management problems and murres, eiders, and Arctic terns have all recently declined due to overexploitation. For example, the number of thick-billed murre breeding colonies has been reduced from 48 to 23 during the last 30 years on the west coast of Greenland (Nordic Ministers Advisory Board, 1999). This is the result of over-harvesting eggs and adult birds. The colonies closest to human settlements have been the most impacted. Prior to the 20th century, communities in Greenland were small and hunting was done from kayaks, which resulted in little impact on seabirds. However, the human population has increased substantially, motorboats and shotguns are now common hunting tools, and the resulting increased harvest has brought about a drastic decrease in the number of formerly large colonies – particularly for murres (Christensen, 2001). Commercial harvests of tens of thousands of birds have been conducted annually since 1990 in southern Greenland municipalities. Most of this hunting pressure takes place in autumn and winter. In northwest and East Greenland seabirds have always been exploited during the breeding period; the only time that they are available in the region. In an attempt to prevent further reductions in the murre breeding population, a closed season was introduced north from Kangatsiaq Municipality in the late 1980s. Subsequent interviews and meetings with hunters showed that illegal hunting continued to be intensive through much of the breeding period (Christensen, 2001). This illegal harvesting, particularly in the Upernavik District, is thought to be a serious threat to breeding colonies. In the small settlements of Avanersuaq and Ittoqqortoormiit, murre shooting is permitted throughout the year. By-catch in fishing nets and increased disturbance near colonies by boat and helicopter traffic are thought to be factors additional to hunting contributing to the reduction in seabird populations. A complete ban was put in force in 1998 on collecting murre eggs, but harvesting continued illegally in some regions (Christensen, 2001). More restrictive legislation on seabird harvesting was put in place on 1 January 2002, but was later retracted due to complaints from hunters. This was followed by attempts to revise existing legislation. Enforced hunting bans will be necessary in some important areas (Christensen, 2001) to bring about population recovery.

A major obstacle for the management and conservation of marine mammals in the North Atlantic, as elsewhere in the Arctic, has been the limited information available on the general biology of marine mammals, their distribution and seasonal movements, use of marine habitats, food chain relationships, and general ecology. This is understandable in view of the difficulty of carrying out research in the marine environment of the Arctic and studying animals that spend most or all of their lives at sea, much of which is below the sea surface. Recently developed technology, however, enables monitoring of movements, feeding behavior, and aspects of the general ecology of marine mammals. These techniques can also provide essential information on the relationship of marine mammals to commercial fisheries, needed to base conservation efforts and to develop management plans (Fig. 11.14)

Fig. 11.14. Recent advances in electronic technology and methodology for handling arctic marine mammals allows for collection of data on movements, seasonal habitat preferences, food chain relationships, and other aspects of their social behavior and ecosystem relationships that were previously unavailable to those responsible for their management and conservation. Shown here (a) on the sea ice adjacent to Svalbard, an anesthetized polar bear is being weighed and other biological data collected prior to its release by a team of scientists from the Norwegian Polar Institute. In (b) a similar team is releasing a beluga whale in the waters adjacent to Svalbard after having glued a package to its back containing environmental sensing instrumentation, a data logger, and a radio transmitter capable of sending data to receivers in aircraft, ships, and polar-orbiting satellites (photos: Kit Kovacs and Christian Lydersen, Norwegian Polar Institute).

11.4.4. Alaskan Arctic

Physical changes in the marine system have the capability to dramatically affect marine species. Marine mammals that depend upon sea ice, such as walrus, polar bears, and the several species of ice seals, use ice as a platform for resting, breeding, and rearing young. While sea ice is a dynamic environment, general seasonal patterns exist and subsistence harvest practices have developed in concert with these seasonal rhythms. Hunters have reported changes in winds, sea-ice distribution, and sea-ice formation that particularly affect hunting (Krupnik and Jolly, 2002). Winds are reported to be stronger now compared with the recent past, and there are fewer calm days. For hunters out in small boats, even a 10 to 12 mph wind creates waves of sufficient size to swamp boats (see Chapter 3). Winds also affect distribution of sea ice. Early season strong winds move sea ice northward and the marine mammals on the retreating ice are quickly out of range of some villages (notably those on St. Lawrence and Diomede Islands, and Shishmaref). Winds can also pack sea ice so tightly against shorelines that hunters are unable to get their boats out. These changes are not predictable, which affects both hunting opportunity and safety. For example, in spring 2001 Barrow whalers made trails at least 50 miles long through the shore ice to reach open leads for hunting. In spring 2002, hunters out on the ice edge became stranded as a large lead unexpectedly developed between their hunting camp and the shore, necessitating a major rescue effort.

Marine mammals are an integral part of the culture and economy of indigenous communities in Alaska, as they have been for centuries. Indigenous people depend on marine mammal species for food and other subsistence needs and utilize all species that are available within Alaskan waters to some degree. The United States is a participant in the 1973 Agreement on the Conservation of Polar Bears and the 2000 U.S./Russia Bilateral Agreement on the Conservation and Management of the Alaska–Chukotka Polar Bear Population. The Alaskan Department of Fish and Game is the state authority dealing with management issues related to polar bears. However, national responsibility for polar bears remains under legislation of the Marine Mammal Protection Act of 1972. Polar bears can be harvested for subsistence purposes or for creating items of handicraft or clothing by coastal dwelling indigenous people provided that the populations are not depleted and the taking is not wasteful. There are no limits on quotas, seasons, or other aspects of the hunt. No commercial hunting or sale of polar bears or their parts are permitted (USFWS, 1994, 2002a,b). Polar bear stocks in Alaska are linked to the east (Southern Beaufort Sea stock) with Canada and to the west (Chukchi/Bering Sea stock) with Russia. A joint agreement exists between the Inuvialuit Game Council, NWT and the Iñupiaq of the North Slope Borough, Alaska for the management of the Southern Beaufort Sea group and negotiations are near completion with Russia for the western areas. Polar bear catches in Alaska vary annually, depending largely on how many bears approach areas near settlements, because there is little targeted hunting effort on this species. The number of bears shot annually in the 1990s varied between approximately 60 and 300. There is no indication that the current level of hunting is not sustainable, although information is lacking for the Chukchi/Bering Sea stock (USFWS, 2002g).

In 1994, an amendment to the Marine Mammal Protection Act of 1972 included provisions for the development of cooperative management agreements between the U.S. Fish and Wildlife Service and Alaska Native organizations to conserve marine mammals and provide for the co-management of subsistence use by Alaskan indigenous people. A mandatory marking, tagging, and reporting program implemented by the U.S. Fish and Wildlife Service in 1988 for some species has provided considerable data for subsistence harvests in recent years. The Indigenous People's Council for Marine Mammals, the U.S. Geological Survey's Biological Resources Division, and the National Marine Fisheries Service and the U.S. Fish and Wildlife Service jointly administer co-management funds provided to the State of Alaska under the Marine Mammal Protection Act of 1972. The U.S. Fish and Wildlife Service works with a number of groups to manage marine mammals in Alaska such as the Alaska Sea Otter and Steller Sea Lion Commission, the Alaska Nanuuq Commission, and the Eskimo Walrus Commission. For example, the Cooperative Agreement developed in 1997 between the U.S. Fish and Wildlife Service and the Eskimo Walrus Commission has served to facilitate the participation of subsistence hunters in activities related to the conservation and management of walrus stocks in Alaska. The agreement has resulted in the strengthening and expansion of harvest monitoring programs in Alaska and Chukotka, as well as efforts to develop locally based subsistence harvest regulations. The mean annual harvest of Pacific walrus over the period 1996 to 2000 was about 5800 animals. However, the hunt has varied quite dramatically from year to year depending primarily on ice conditions and hunting effort, and has varied between 4000 and 16 000 animals per year over the 1980s and 1990s (USFWS, 2002c). Sustainable level of harvest cannot be prescribed because of a lack of information on population size and trend, but the population is thought to number in excess of 200 000 animals, having recovered dramatically from heavy exploitation early in the 20th century. Other seals, such as ringed seals, bearded seals, harbour seals, and spotted seals (*Phoca largha*) are important in the diet of indigenous people in Alaska and are harvested in significant numbers.

Sea otters (*Enhydra lutris*) were heavily depleted by commercial harvests during the 1700s, and probably numbered only a few thousand animals in 13 remnant colonies when they became protected by the International Fur Seal Treaty in 1911 (USFWS, 2002d,e,f). Following protection and translocation of animals, they recovered and re-colonized much of their historic range in Alaska. Sea otter populations in southcentral Alaska and those reintroduced into southeast Alaska are growing and each of the two stocks is subject to a subsistence harvest of about 300 animals. The southwestern Alaskan stock in the Aleutian Islands is undergoing a population decline that is not explained by the level of human-induced mortality. Heavy predation by killer whales, previously not known to be a significant predator on sea otters, has been reported and postulated as a cause for the decline (Estes et al., 1998). This apparent shift in trophic level relationships is also thought to be tied to other changes brought about through heavy commercial fishing pressure and warming of these marine waters through strong El Niño events and climate warming (Benson and Trites, 2002).

The northern fur seal historically underwent population reductions through heavy commercial harvests both at breeding colonies and at sea. It then was managed by international treaty through the North Pacific Fur Seal Commission. Commercial hunting of this species was terminated in 1985. However, like the sea otter in the west and several other marine mammal populations including Steller sea lions (*Eumetopias jubatus*) (Loughlin, 2002) and harbour seals (Boveng et al., 2003), the fur seal has been declining since about 1990 at a rate of 2% per year (Gentry, 2002) despite small subsistence harvests. The current marine mammal population declines in the Bering Sea and North Pacific appear to be part of a complex regime shift that is thought to be the result of temperature shifts that caused several major fish stocks to collapse and the impacts are cascading through the system (e.g., Benson and Trites, 2002). The collapse of these fish stocks, however, may be tied to the intense commercial exploitation of the Bering and North Pacific fisheries. Management responses to the population declines have been undertaken through a host of plans and agreements, such as the Co-management Agreement between the Aleut community of St. George Island and the National Marine Fisheries Service that was signed in 2001 to address management of the northern fur seal and Steller sea lion at St. George Island (NMFS, 2001).

Fig. 11.15. The bowhead whale harvest at Barrow, Alaska is carried out under a regional harvest quota established by the Alaska Eskimo Whaling Commission (photo: Department of Wildlife Management, North Slope Borough).

Subsistence hunting of bowhead, gray, beluga, and minke whales takes place in Alaska (Fig. 11.15). At the local level the Alaska Eskimo Whaling Commission regulates whaling activities. Eskimo whaling is conducted from nine traditional whaling communities. The current quota of 51 bowhead whales is hunted from St. Lawrence Island and Little Diomede Island in the Bering Sea and from coastal villages along the northern Alaskan coast. This hunt was not sanctioned by the International Whaling Commission in 2002 (IWC, 2002), however, an emergency session of the commission in 2003 agreed on a new quota for the Alaskan subsistence harvest. The bowhead is classified as an endangered species. The beluga is the second most important cetacean species harvested for subsistence in Alaska and it is hunted in significant numbers. The Alaska Beluga Whale Committee oversees this hunt. The gray whale quota, which is sanctioned by the International Whaling Commission, is 140 animals per year in the eastern North Pacific (620 animals from 2003 to 2006). This species was removed from the endangered species list in 1995 following a dramatic recovery in the eastern Pacific; western Pacific stocks (off Korea) have not recovered and remain listed. Minke whales are opportunistically taken in Alaska.

Seabird harvests in Alaska are managed through a co-management council that includes indigenous, federal, and State of Alaska representatives that provide recommendations to the U.S. Fish and Wildlife Service and North American Flyway Councils. The latter bodies are included because most harvested species fall under the North American Migratory Bird Treaty Act that prohibits hunting from 10 March until 1 September, but provisions for Alaska provide that indigenous inhabitants of the State of Alaska may harvest migratory birds and their eggs for subsistence uses at any time as long as there is no wasteful taking of birds or eggs. Seabirds and their eggs cannot be bought or sold in Alaska. Subsistence harvest information is only available for the last decade, and these statistics are thought to represent minimal harvest estimates. The two most harvested species are crested auklet (*Aethia cristatella*) (about 12 000) and common murre (about 10 000) (CAFF, 2001b; Denlinger and Wohl, 2002). Smaller numbers of other seabirds taken include: cormorants, gulls, common loons (*Gavia immer*), red-legged kittiwakes (*Rissa brevirostris*), black-legged kittiwakes, yellow-billed loons (*G. adamsii*), thick-billed murres, least auklets (*Aethia pusilla*), parakeet auklets (*A. psittacula*), Pacific loons (*G. pacifica*), Arctic loons (*G. arctica*), red-throated loons (*G. stellata*), ancient murrelets (*Synthliboramphus antiquus*), tufted puffins, Arctic terns, and horned puffins. Harvests from St. Lawrence Island communities dominate the overall harvest statistics. The ten-year average for eider harvests are common eider 2000, king eider (*Somateria spectabilis*) 5500, spectacled eider (*S. fischeri*) 200, and Steller's eider (*Polysticta stelleri*) 50. Seabird egg collecting is more evenly spread geographically than the hunting of birds, with eggs of gulls, murres, and terns being the most commonly harvested (Denlinger and Wohl, 2002). More information is needed on population trends and the harvests themselves as a basis for establishing sustainable harvest levels. Harvest by humans, however, is not recognized by the U.S. Fish and Wildlife Service as a threat to seabirds in Alaska (USFWS, 2001). Recommendations for regulations governing harvest of game and non-game birds for each season are adopted by the Co-management Council and then forwarded to the U.S. Fish and Wildlife Service for action. These include seasons, bag limits, restrictions on methods for taking birds, law enforcement policies, and recommendations for programs to monitor populations, provide education for the public, assist integration of traditional knowledge, and instigate habitat protection (CAFF, 2001a).

A new conservation tool for seabirds and their habitats is Important Bird Areas (IBAs). The program was started in Europe in 1989 by Birdlife International and has grown into a worldwide wildlife conservation initiative. The goal of the IBA program is to get indigenous people, landowners, scientists, government agencies, non-governmental organizations, and land trusts to work together and set priorities for bird conservation. There are criteria regarding high concentration areas and rare species that are considered for inclusion into the IBA program. In Alaska, Audubon Alaska has recently completed a draft list of IBAs for the Bering and Chukchi Seas. While IBAs are for all birds, the ones identified in Alaska were mostly set up because of high concentrations of seabirds. There are 138 sites, the majority of which are in the Bering Sea (Fig. 11.16).

11.4.5. Future strategies

A changing environment will result in changes in subsistence hunting patterns. Harvest levels may decrease for some species as their seasonal availability decreases, while for others, harvest levels may increase. Close documentation of harvest levels and patterns will be needed to track these changes and to contribute to site-specific information on wide-ranging species. Hunter participation in collection of population and other biological information is essential for effective marine mammal management. Changes in health of walrus were reported in 2000, when hunters reported that adults appeared skinny and that few calves were present, potentially reflecting poor access to food resources. For ice-dependent species that are difficult to study directly, information from subsistence-harvested animals can be of considerable value for their management. In addition, hunters are interested in and concerned about changes they are observing. Should harvest restrictions become necessary, direct involvement of the subsistence community in developing the restrictions will facilitate such changes.

Marine mammals, throughout most of the Arctic, are the primary subsistence food base for coastal residents of the Arctic. Seabirds, including eiders and other sea ducks,

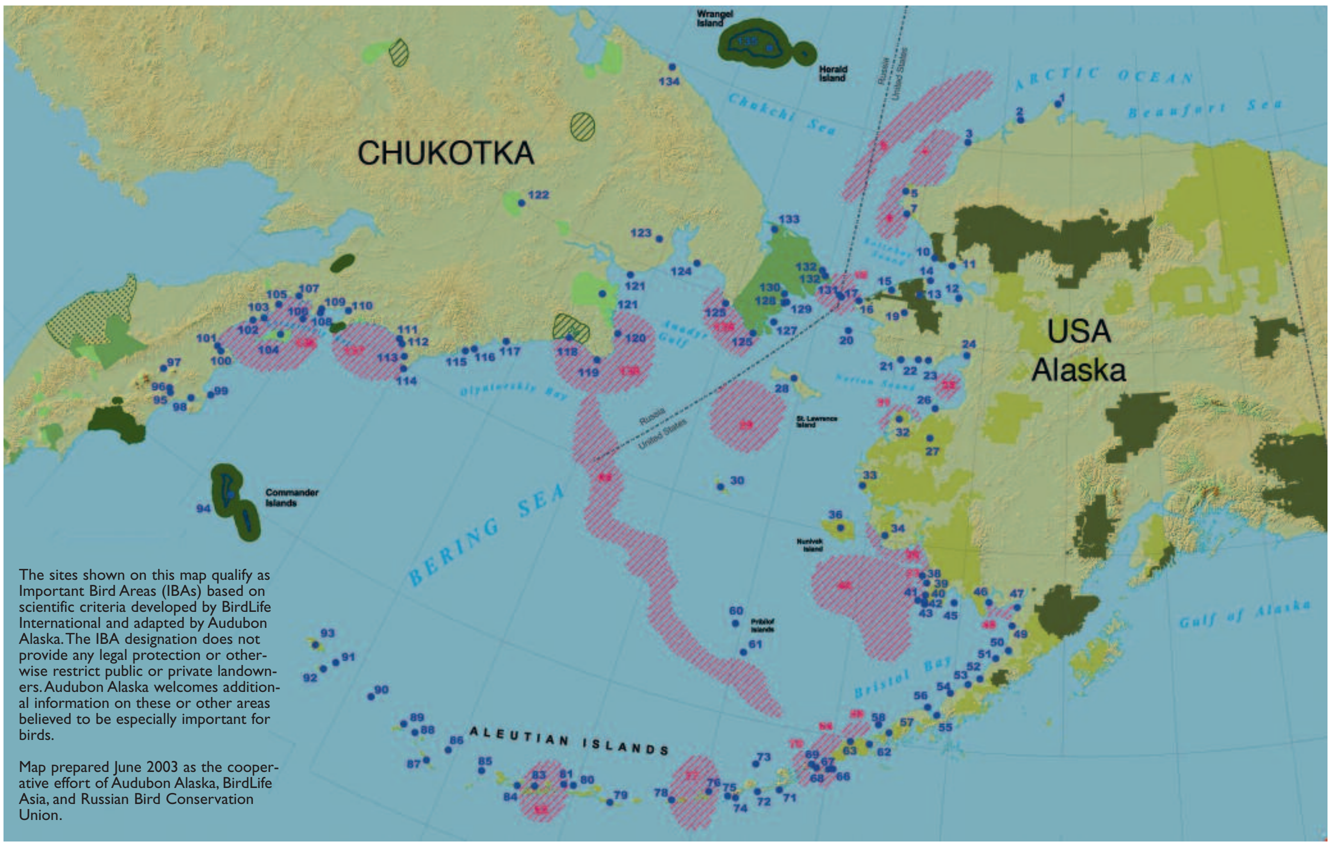

Fig. 11.16. Important Bird Areas in the Bering and Chukchi Sea regions. These have been generated through cooperative efforts of scientists in government agencies and non-governmental organizations, working with indigenous people and other coastal residents in Russia and the United States. The map is an essential step in the planning for a network of protected areas critical for the conservation of seabirds and their habitats in the Bering–Chukchi region (map supplied by the National Audubon Society).

alcids, and gulls, are also important to many coastal communities as a source of food. In some areas seabirds are also harvested commercially. The most productive regions for seabirds in the Northern Hemisphere are between approximately 50º and 70º N. Well over 100 million seabirds live in these arctic and subarctic regions, an order of magnitude more than seabirds living in the temperate regions (Croxall et al., 1984). The management implications of climate change are complicated and largely unknown, but increasing temperatures, thawing of the sea ice with associated movement of the pack ice edge northward, and rising sea levels will cer-

Table 11.6. Population trends, management, and threats to marine birds in the Bering, Chukchi, and Beaufort Seas.

	Population trends: Bering Sea	Population trends: Beaufort and Chukchi Seas	Management regulations[a]	Harvest birds	Harvest eggs	Threats[b]	Status[c]
Common loon	Unknown	Unknown	Yes	Yes	Yes	1,2,3,4,5,6,7	3
Yellow-billed loon	Unknown	Stable	Yes	Yes	Yes	1,2,3,4,5,6,7	2
Pacific loon	Stable	Stable	Yes	Yes	Yes	1,2,3,4,5,6,7	3
Arctic loon	Unknown	Unknown	Yes	Yes	Yes	1,2,3,4,5,6,7	3
Red-throated loon	Decrease	Stable	Yes	Yes	Yes	1,2,3,4,5,6,7	2
Short-tailed albatross	Increase	N/A	Yes	No	No	3,5,6,7	1
Black-footed albatross	Decrease	N/A	Yes	No	No	3,5,6,7	2
Laysan albatross	Decrease	N/A	Yes	No	No	3,5,6,7	2
Northern fulmar	Increase	N/A	Yes	No	No	3,7	3
Fork-tailed storm petrel	Increase	N/A	Yes	No	No	3,7	3
Double-crested cormorant	Unknown	N/A	Yes	No	No	1,3,7	3
Pelagic cormorant	Decrease	Unknown	Yes	Yes	No	1,3,7	3
Red-faced cormorant	Unknown	N/A	Yes	Yes	Yes	1,3,7	2
Common eider	Stable	Decrease	Yes	Yes	Yes	1,3,6,7	3
King eider	N/A	Decrease	Yes	Yes	Yes	1,3,6,7	2
Spectacled eider	Stable	Stable	Yes	Yes	Yes	1,2,3,6,7	1
Steller's eider	Unknown	Unknown	Yes	Yes	Yes	1,2,3,6,7	1
Herring gull	Unknown	N/A	Yes	No	Probable	7	3
Glaucous-winged gull	Decrease	N/A	Yes	Probable	Yes	7	3
Glaucous gull	Unknown	Unknown	Yes	Probable	Yes	7	3
Red-legged kittiwake	Decrease	N/A	Yes	Yes	Yes	7	2
Black-legged kittiwake	Decrease	Increase	Yes	Yes	Yes	7	3
Arctic tern	Unknown	Unknown	Yes	Yes	Yes	4,7	2
Aleutian tern	Unknown	Unknown	Yes	No	Yes	4,7	2
Common murre	Decrease	Stable	Yes	Yes	Yes	1,3,7	3
Thick-billed murre	Stable	Stable	Yes	Yes	Yes	1,3,7	3
Black guillemot	N/A	Decrease	Yes	No	No	1,7	3
Pigeon guillemot	Unknown	N/A	Yes	Yes	No	1,3,6,7	3
Marbled murrelet	Unknown	N/A	Yes	No	No	1,3,4,5,7	2
Kittlitz's murrelet	Unknown	N/A	Yes	No	No	1,3,4,7	2
Ancient murrelet	Unknown	N/A	Yes	No	No	1,7	2
Cassin's auklet	Unknown	N/A	Yes	No	No	1,7	3
Parakeet auklet	Unknown	N/A	Yes	Yes	Yes	1,7	3
Crested auklet	Unknown	N/A	Yes	Yes	No	1,7	3
Whiskered auklet	Unknown	N/A	Yes	No	No	1,7	2
Least auklet	Unknown	N/A	Yes	Yes	No	1,7	3
Horned puffin	Unknown	Unknown	Yes	Yes	Probable	1,7	3
Tufted puffin	Increase	N/A	Yes	Yes	Probable	1,3,7	3

N/A not applicable; [a]Regulated within the 3 nautical mile territorial waters zone by the U.S. Migratory Bird Treaty Act; [b]1:oil pollution, 2:over-harvest, 3: fisheries by-catch, 4:human disturbance, 5:habitat alteration, 6:contaminants, 7:climate change; [c]1:Threatened or Endangered (U.S.), 2:Birds of Conservation Concern (U.S.), 3:Low or moderate concern.

tainly reduce the availability of seabirds as food to many arctic communities. This will complicate the role of management to ensure the health of seabird populations as components of ecosystems undergoing change, while providing for the sustainable use of the seabirds by the people that depend upon them. A further complication in assessing how seabirds may move northward and possibly establish new nesting colonies within the context of a warmer climate is the difficulty of predicting how the marine food species upon which seabirds are dependent may change their distribution and productivity in relation to climate change and other human impacts such as commercial fisheries.

11.4.5.1. North Pacific, Bering, Chukchi, and Beaufort Seas

If temperatures increase for sustained periods, with associated melting of Arctic Ocean ice, and the band of high seabird productivity shifts northward, there is likely to be a dramatic overall decline in the number of seabirds living in the arctic and subarctic regions of the North Pacific and adjacent Arctic Ocean where high latitude nesting islands are extremely limited. This is particularly apparent when contrasting the rugged island and coastal topography of the southern Bering Sea with the low-lying coastal plains that border much of the northern Bering, Chukchi, and Beaufort Seas. A different situation exists in the North Atlantic and Canadian High Arctic because of more high latitude islands with rugged coastal topography that might serve as new nesting sites. In addition, if the sea level rises as projected as a consequence of climate warming, many low-elevation nesting islands used by eiders, terns, and gulls will be inundated, resulting in decreased numbers of these species.

Estimates of population trends and status, current management, and threats for arctic seabirds of the North Pacific and associated Arctic Ocean, including the Bering, Okhotsk, Chukchi, and Beaufort Seas, are summarized in Table 11.6. Presently there is little or no information on population trends of many seabird species nesting in the Arctic. Better data on population trends are critical for effective management and conservation of these species, especially in areas where they are harvested for human use.

11.5. Critical elements of wildlife management in an Arctic undergoing change

The expected effects of climate change on arctic wildlife have been addressed in other chapters, particularly Chapters 7 (tundra and polar desert ecosystems), 8 (freshwater ecosystems and fisheries), and 9 (marine systems). Chapters 3 (indigenous perspectives), 12 (hunting, herding, fishing, and gathering), 13 (marine fisheries and aquaculture), and 14 (forests and agriculture) assess human relationships to climate change in the Arctic via commercial and subsistence harvest of resources, land use practices, and socio-cultural change. The latter chapters assess the interface between people and the natural biological systems of the Arctic, recognizing that people of the Arctic are both components of arctic ecosystems as well as major drivers of these systems. Humans living outside the Arctic have become a major driving influence on arctic systems as a consequence of their industrialization and associated urbanization, accelerated pressures for exploitation of the world's non-renewable mineral and energy resources, globalization of the economy, and exportation of their cultural, social, and economic values and aspirations. These pressures, largely generated at temperate latitudes, reach into the Arctic through their effects on climate, atmospheric and marine pollution, and their social, economic, and cultural influences on the human and nonhuman residents of the Arctic.

11.5.1. User participation

This chapter deals primarily with assessment of the effectiveness of existing structures for management and conservation of wildlife in the Arctic and the adaptability of these structures to changes that are expected to continue and to accelerate in the Arctic in the future. A comparative analysis of the existing arrangements and their processes of evolution would serve as the basis for assessing the capacity of management to meet the challenges that may come with various climate change scenarios. While it is not possible to determine with a high level of specificity the nature of these challenges, it can be assumed that managers and users of arctic wildlife resources will be confronted with increased variability, a greater likelihood of surprise, and rapid change which may stress even the most robust wildlife institutions. It is, however, important to recognize that climate change, although of major consequence for arctic systems, is one of several driving forces influencing the broad spectrum of accelerated changes that are occurring in the Arctic. These forces of change, the climatic, the economic, the social, the cultural, and the political, operate through influences both internal to the Arctic as well as those of a global nature. It therefore follows that management and conservation of wildlife in the Arctic should serve the interests of all those, both within and outside the Arctic, who would use and value the wildlife of the Arctic. Responsibility for management and conservation of arctic wildlife, therefore, extends to the entire global community.

A major political change has taken place in the Arctic in recent decades bringing increased regional autonomy and a stronger voice for the residents of the Arctic in managing their own affairs. This has major consequences for wildlife conservation and management in the Arctic. The increased interest in, and broader participation by, residents of the Arctic in management of the species of importance to them should receive major emphasis in the design of systems for conservation and management of wildlife in all regions of the Arctic where indigenous peoples reside. Existing systems that have incorporated the concept of participation in, and shared responsibility for, wildlife management by residents of the Arctic who are the users of the wildlife are often referred to as co-management. These management systems have proved preferable to the wildlife users, have improved the collection of biological and harvest information on the target species, served as a means for integrating traditional knowledge and science, and have increased efficiency in managing wildlife for sustained harvest and conservation. These regimes vary in the degree to which they are based on formal legal standing and reflect the cultural, ecological, and economic conditions in which they emerge. Examples are: 1) the Canadian Beverly-Qamanirjuaq Caribou Management Board, a highly complex management system spanning several jurisdictions and involving numerous groups, some of whom have settled land claims and others that have not; 2) the Canadian Porcupine Caribou Management Board, which is relatively simple in composition compared to the Beverly-Qamanirjuaq arrangement and interfaces with the United States–Canada caribou management system that provides limited authority to Alaskan caribou user communities; 3) the Alaska Eskimo Whaling Commission, which is homogenous in composition and highly effective when interacting at the international level; and 4) the Inuvialuit–Inupiat Beluga Commission, a strong bilateral arrangement where there are few third-party interests and local resource users have significant influence. While the range of conditions for joint management differ, the conditions of sharing the responsibility for the conservation and management of wildlife between users of the wildlife and the governmental units that have legal jurisdiction over the lands, waters, and their resources in the Arctic has generally proved workable and effective. Legal jurisdiction over wildlife in large regions of the Arctic is often shared between governments and indigenous peoples through treaties, land claim settlements, and other governmental agreements that influence how co-management systems can be developed and how authority over wildlife is partitioned.

How, if at all, might principles of co-management be applied to regions like Russia, where local resource users have limited legal rights and non-local interests commonly influence policy making? To what extent is co-management possible in regions where traditionally semi-nomadic reindeer herders hold no title to land? What are the limits to co-management for addressing the problems of climate change in Alaska under the existing system of state–federal dual management? These questions highlight the need for more in-depth comparative research in this area of institutional analysis.

Wildlife management has always been a source of contention among wildlife users, and the adoption of co-management systems must be accompanied by trial periods to ensure that both government managers and wildlife user representatives have time to learn the process and accept their relative responsibilities prior to passing judgment on the effectiveness of the system. A major question raised is, can co-management systems manage wildlife populations, assuring their sustained production and conservation, if they become alarmingly depressed as a consequence of climate change or other causes? It seems reasonable to expect that effective management under such difficult conditions, whatever the management system, would require the ability to investigate causes of the population change as a basis for prescribing management action. If the users of wildlife are acknowledged to be a source of information about wildlife ecology, as well as participants in wildlife surveys and scientific investigations, then achieving an understanding of the relative importance of population regulatory mechanisms seems more likely than in management systems in which the users play no active role and managers live remote from the system (Klein et al., 1999). In a similar context, when management decisions are made within a true co-management system, the users, through their representation on the management board, are participants in a democratic process and are therefore more inclined to accept and comply with restrictive regulations than if management decisions are made by a remote governmental authority. Although regulations established through the co-management process may be more acceptable and complied with by the majority of resource users than regulations imposed from outside the region, total agreement is unlikely, and enforcement of harvest regulations is as important as in other management systems.

11.5.1.1. Lateral collaboration and cooperation

In addition to the hierarchical structure of management systems that are vertically structured within national or international jurisdictions, there is need for increasing lateral connections that result in sharing of knowledge, experience, and responsibility for wildlife management and conservation. Lateral connections can include increased interaction between communities sharing a common wildlife resource, between a community and an industrial development activity that both affect a wildlife resource but in differing ways, and region-to-region communication regarding experiences and knowledge about management of similar species. An example of the latter is the "Profile of Herds" concept being developed through an International Arctic Science Committee project. It provides a basis for inter-herd comparison of the management and conservation of caribou and wild and domestic reindeer. The project has as its goal the collation and organization of data on population status and dynamics, management practices, human interactions (herding, hunting, subsistence and commercial uses, and cultural relationships), and range size and characteristics of caribou and reindeer in a circumpolar context. The data are being archived through Environment Canada and the Institute of Arctic Biology at the University of Alaska Fairbanks, with access via www.rangifer.net. These files on caribou and reindeer herds throughout the Arctic and subarctic will enable ongoing comparison of harvest methods and levels, predator relationships, range conditions, and carrying capacity under varying climatic, environmental, and human influences, and under differing management regimes. Caribou and reindeer share common ecological relationships with their environment that are characteristic of the species, however, the relative importance of the driving variables within their environment may vary widely over the total range of distribution of the species. The capability to compare the relative effectiveness of a given herd management system with others throughout the North should assist in adapting management systems and practices in response to changes brought about by climate, industrial impacts on herd ranges and habitats, trends in subsistence and economic needs, and evolving indigenous cultures.

11.5.2. A regional land use perspective

In order to effectively manage wildlife within an environment of change in the Arctic, basic inventories of wildlife populations and their dynamics, and investigation of ecosystem relationships of wildlife on a regional basis are a prerequisite, as well as providing early warning indicators (Fig. 11.17). This information is critical to meet proximal needs of management for prescribing methods, means, and seasons of harvest and for setting harvest quotas. Inventory information is also critical for longer-term monitoring of animal populations and ecosystem relationships as a basis for assessing changes in distribution, movements, and population trajectories that may be the consequence of climate change or other human-induced changes in the natural environment. Basic inventory data on wildlife, wildlife habitats and movements, and patterns of human use of wildlife are also of critical importance in assessment of impacts of proposed development projects.

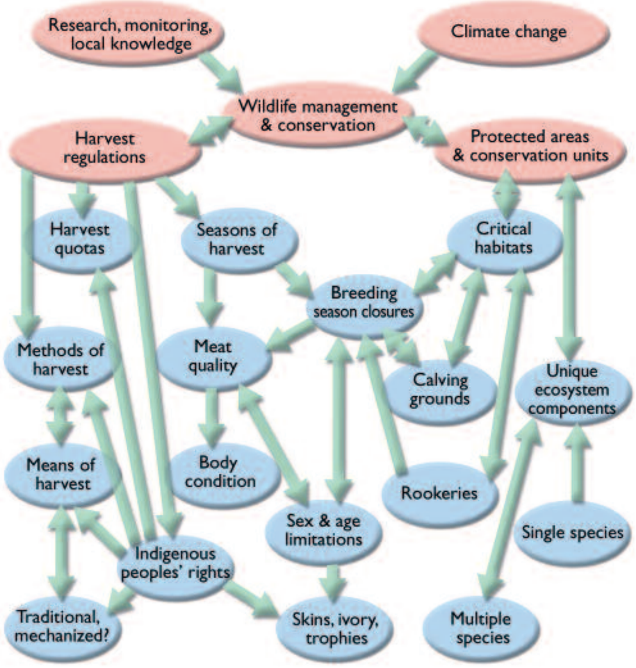

Fig. 11.17. Effective management of wildlife and its conservation involves accumulation of knowledge of animal population biology and ecological relationships through research, monitoring, and accessing local knowledge. This then provides a basis for defining critical habitats and providing for their legal protection, and for establishing wildlife harvest regulations with local involvement to ensure sustainability of wildlife populations with continuing opportunity for their harvest.

Needs for effective management and conservation of wildlife in a changing Arctic vary regionally. For example, to deal with threats to management and conservation of wildlife in the Russian North and to return effective wildlife management to the Russian Arctic and subarctic, the following changes in existing structures for management and their application are widely acknowledged as needed:

- adaptation of existing wildlife management systems consistent with existing social and economic conditions, constraints, and opportunities;
- elaboration of legal and economic mechanisms for protection of wildlife resources and habitats to ensure sustainability of wildlife populations and their production in conjunction with industrial resource development;
- elaboration of legal and economic mechanisms for protection of traditional hunting cultures in conjunction with industrial resource development;
- increasing the effectiveness and the technological level of commercial hunting, the processing of wildlife products, and their marketing consistent with resource conservation; and
- systematically organized inventory and monitoring of wildlife resources based on both scientific and traditional knowledge and methodology.

These needed changes, however, are not unique to Russia, and are basic to effective wildlife management and conservation throughout the Arctic. It is the needed focus on these structural components of management that is particularly timely in Russia in the current post-Soviet transition period.

The process of development of regional land use plans, with adequate wildlife inventory data available, enables layout of proposed human activities on the land, such as roads, communities, and other structures, in consideration of protection of wildlife habitat values, movement routes, and patterns of human use of the wildlife. Development of regional land use plans based on adequate wildlife inventory data should enable designation of protected areas to encompass critical wildlife habitats, such as caribou calving grounds, wetland bird nesting habitats, and coastal haul-out sites and nesting colonies of critical importance for marine mammals and birds. However, regional land use plans must be subject to periodic revision, based on continuing wildlife inventory and monitoring data, and therefore be adaptable to environmental change brought about through changes in climate, and the continuing and cumulative consequences on the land of all human activities. Thus, areas designated to protect critical wildlife habitat units may at times need to be altered through expansion, relocation, or removal of protection in response to major changes in wildlife distribution and habitat use brought about through climate-induced or other changes in the environment.

If land use plans are in place in arctic regions prior to proposals for large-scale industrial development projects, such as energy or mineral extraction, hydropower development, construction of roads, railroads, pipelines, and power-lines, initial decisions on the feasibility of proposed projects will be simplified. Project planning can proceed with knowledge of regional wildlife values that need to be protected, critical habitats that need to be avoided, and provisions necessary for the sustainable harvest and other uses of wildlife. The controversy, associated political polarization, and animosity that often develops among interest groups over proposed development projects in the Arctic can be minimized if comprehensive land use plans have been prepared. Efforts to develop comprehensive regional land use plans involving local residents and government are currently underway in a few regions of the Arctic. Examples include the Swedish MISTRA project, *Sustainable Management of the Mountain Region*, that includes assessment of the natural resources in the mountains of northern Sweden, their levels of use, and their economic and socio-cultural relationships within and outside the region in development of a land use plan aimed at long-term community and resource sustainability; and the Canadian *Yukon North Slope Wildlife Conservation and Management Plan* of a similar nature that evolved from the joint Alaska and Yukon *Community Sustainability Project*. Reindeer and caribou, and their ecosystem relationships and associated human dependency on them, have provided initial stimuli for development of these land use plans. Wild reindeer and the indigenous cultures that evolved in association with them are also the focus of recently initiated land use investigations in the Taymir of the western Siberian Arctic through the *Taymir Reindeer Project*, which is a first stage in development of a regional land use plan.

The concept of regional land use planning as a basis for management and conservation of wildlife in an environment of change also has application in the marine environment. In most of the marine environment of the Arctic, offshore petroleum exploration and production and permanent infrastructure development has not been at all comparable to that on land. Nevertheless, the need for protection of critical wildlife habitats and associated ecosystem relationships is as important in the marine environment as it is on land. The international or binational nature of many species of marine wildlife clearly requires international efforts in the development of marine area use agreements to ensure protection of critical habitats for marine wildlife. Planning processes for where to place major shipping routes, where bottom trawling can take place without irreversible damage to benthic systems, where ship-based tourist traffic can be focused to provide good experiences while minimizing effects on wildlife, and where restrictions on icebreaking activity might be essential to protect breeding habitats of seal species all require information that is very similar to that needed to assess land-based human development activities in the Arctic. Marine ecosystems in the Arctic, and worldwide, are less well known than terrestrial ecosystems, largely because humans are land-dwelling creatures with limited capabilities for operating below the surface of the sea. The task of carrying out needed research to understand ecosystem relationships of marine wildlife that spend major parts of their life cycles beneath the sea surface is, therefore, more complex. However, inventory and monitoring methods for assessing marine wildlife abundance are developing rapidly, as is tracking technology needed to record movement patterns and habitat use. So, although marine research tends to be more costly than terrestrial studies, a great deal is now possible that is highly relevant to developing good, responsive management practices.

Integral to the effective use of regional land use planning as a basis for management and conservation of wildlife in the Arctic is assessment of the cumulative impacts of development projects that have taken place within the region. Although environmental impact assessments of proposed major projects are now prescribed by government policy in most arctic countries, these assessments have been restricted to the project under consideration and have rarely considered the cumulative impacts on wildlife to which the proposed project would contribute. A recent assessment of the cumulative impacts of petroleum development in the Alaskan Arctic requested and financed by the U.S. Congress has pointed out major consequences for wildlife that have affected their management and conservation, and that were not anticipated through environmental assessments required for the individual projects (NRC, 2003).

11.5.3. Concluding recommendations

Shared responsibility for management and conservation of wildlife in the Arctic requires involvement, cooperation, and collaboration among all interest groups. Indigenous peoples of the Arctic, the majority of whom are dependent on annual harvests of wildlife for the subsistence component of their economy, are gaining increased, and often primary, responsibility for management of local harvests of wildlife. In most of the Arctic it is the indigenous peoples who will play the key role in management and conservation of wildlife (Klein, 2002). Many of the non-indigenous residents of the Arctic are also consumptive users of wildlife and depend upon wildlife as a supplement to their economy. Direct involvement of the users of wildlife in its management at the local level has the potential for rapid management response to changes in wildlife populations and their availability for harvest. Rapid response to changes in numbers and distribution of wildlife is a prerequisite for effective management of many resident species of arctic wildlife and their conservation under present conditions of limited predictability of ecosystem response to climate change, and is an important component in management of migratory species often requiring international collaboration.

Non-consumptive use of wildlife through viewing and photography, as part of tourism in the Arctic, can affect wildlife through disturbance and stress during sensitive periods in their annual cycle, by displacement from habitats, or through attraction to food wastes. Management of the relationship of tourism to wildlife in the Arctic requires collaboration between management regimes at regional, national, and international levels. Since marine species of wildlife are among the most accessible, and therefore attractive to tourists visiting the Arctic, ship-based tourism poses a major threat to arctic wildlife. Establishment of specific areas to ensure protection from excessive disturbance at breeding sites will continue to be an important part of wildlife conservation in the Arctic in an environment of change. Most tourism companies operating in the Arctic are based outside the Arctic, thus guidelines and regulations for management of tourism impacts on wildlife must include bi-national or international processes and cooperation. Assuring compliance with guidelines and enforcement of regulations also requires cooperation among countries that share wildlife resources that are the focus of the tourism industry.

Many wildlife species of importance as food and other components of the economy of arctic residents are migratory and therefore spend parts of their annual life cycles in different ecosystems, some of which may be at great distances from the Arctic. Migratory wildlife are necessarily subject to management responsibilities that transcend local interests, whether they move with the annual advance and recession of sea ice as many marine wildlife do, whether they travel overland seasonally to track food quality and availability characteristic of caribou and reindeer, or whether they journey through many thousands of kilometers from the Arctic to wintering areas as do most arctic nesting birds and many whale species that feed in arctic waters during the summer months. Management and conservation of migratory or wide-ranging species requires broad participation by all those with interests and responsibilities for arctic wildlife. This requires that management be expanded from local jurisdiction to include regional, national, and international collaboration and shared responsibility in management of migratory and wide-ranging wildlife. Spreading responsibility for management and conservation of wildlife over broader geographical interests is clearly important where it is not possible for those responsible at the local level to be aware of the status and ecosystem relationships of wildlife species after they have left the local area. Sharing the responsibility for management also generally results in greater total effort expended for the collection of biological and harvest information needed to ensure the well-being of wildlife populations. This may improve the chances for early detection of responses of migratory wildlife to the effects of climate change. Conversely, achieving action deemed necessary for management of migratory wildlife to compensate, correct, or adapt to climate-related changes may be difficult and drawn out because of bureaucratic complexity inherent in international governing bodies. Where international overseeing may be justified and needed for aspects of arctic wildlife management and conservation at the policy level, efficient and more timely execution of policy through management actions may be possible through a reduction in bureaucratic layering by delegation of authority to bi-regional or multi-regional councils or committees whose membership is representative of the specific national interests involved. Such management bodies would be most effective if their focus and responsibility were restricted to a single species (e.g., beluga whales) or a group of ecologically similar species (e.g., seabirds) and their membership included local users of the wildlife.

The role of international agencies and organizations in wildlife management and conservation is particularly important with regard to the insidious consequences of pollutants and contaminants entering arctic food chains largely from sources outside the Arctic. Inventories and monitoring of the pollutants and contaminants entering arctic ecosystems, and research on their consequences for the health of arctic wildlife as well as the health of the arctic residents who consume the wildlife, are critical to management of arctic wildlife. An understanding of the role of pollutants and contaminants in wildlife food chains, wildlife health, and associated human health, and the influence of climate change on these relationships, underlies interpretation of the consequences of other environmental variables on wildlife, which is basic to management and conservation of wildlife in the Arctic. Clearly, international oversight, coordination, reporting, collating of information, and associated stimulation of national efforts are needed to better understand the importance of pollutants and contaminants entering the Arctic. The reduction of levels of pollutants and contaminants entering the Arctic, and management of their impacts on arctic wildlife, will require action at the national level through joint international efforts.

Achieving effective conservation and management of wildlife in a changing Arctic will require a team-building approach among governments at all levels that relate to the environment and human well-being, and with all other groups with an interest in the Arctic. This effort should include the indigenous peoples and other residents of the Arctic, and scientists undertaking research in the Arctic, representatives of industry and business seeking development of arctic resources or other economic opportunities in the Arctic, those who travel to the Arctic for recreation or tourism, and the non-governmental organizations seeking to protect or sustain environmental, aesthetic, and other less tangible values of the Arctic in the broader interest of society. Interests in the Arctic by these diverse groups are often overlapping and sometimes conflicting, but the successful management and conservation of arctic wildlife requires that these groups be represented in the management process and that adequate information is available for equitable consideration of the diverse interests that relate to arctic wildlife. The role of international, non-governmental environmental organizations is particularly important in maintaining focus of the public on the broad spectrum of environmental values existing in the Arctic when proposals for large-scale industry- or government-sponsored projects become politicized at the regional or national levels.

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Appendix. Canadian co-management of the Porcupine Caribou Herd, toward sustainability under conditions of climate change

Climate change projections are an additional factor that must be incorporated into co-management considerations. As it is unclear if and how humans can affect the trajectories of climate change, the ultimate effects of climate change on indigenous caribou hunting societies are likely to depend on the capacity of their management systems to detect change, decipher its implications, and facilitate human adaptation in ways that meet societal needs. Also, it will be difficult to differentiate possible effects of climate change on the ecology of caribou from other human-induced influences, such as habitat fragmentation or disturbance from industrial development, construction of transportation corridors, or expanding tourism. Thus, there is a need for caribou management arrangements to be highly adaptive in their approach, and thus more resilient.

Porcupine Caribou and their environment

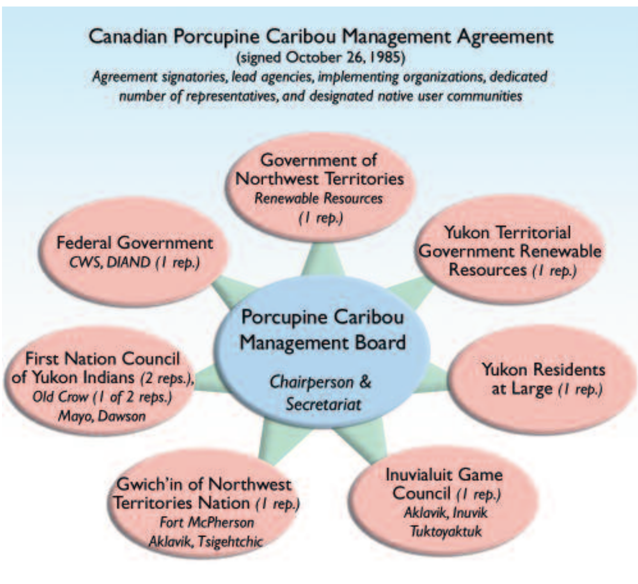
The Porcupine Caribou Herd is one of approximately 184 wild *Rangifer tarandus* herds (102 in North America), is the eighth largest herd in North America, and the largest shared migratory herd of mammals of the United States and Canada. The Porcupine Herd has been monitored and the subject of intensive research since the early 1970s. The population has grown at about 4% per year since the early 1970s to a high of 178000 animals in 1989. During this period all major herds increased throughout North America. The synchrony in the population trends of these herds suggests that they have been responding to continental-scale events, presumably weather-related. Since 1989 the herd has declined at 3.5% per year to a low of 123000 in 2001. Compared to other migratory herds across North America, the Porcupine Herd has the lowest growth rate and one of the highest adult cow mortality rates (Griffith et al., 2002).

Institutional and organizational features of the Porcupine Caribou Herd management system

From an institutional and organizational viewpoint, the Porcupine Caribou Herd system is complex, including two nation states, seven indigenous claimant groups, three territorial/state-level governments, and approximately 17 local communities (see Kofinas, 1998). This complexity contains important contrasts, including legal and cultural differences between U.S. and Canadian governance systems, and highlights the need for coordination of activities in uses of the herd and its habitat.

Two agreements specifically contain language for this type of coordination and provide for Canadian local community involvement. These agreements are the Canadian Porcupine Caribou Management Agreement and the Agreement between the Government of Canada and the Government of the United States of America on the Conservation of Porcupine Caribou. This case study deals primarily with the Canadian agreement. The Canadian Porcupine Caribou Management Agreement was signed in 1985 by federal and territorial governments and indigenous organizations of the region. The agreement is implemented by the Porcupine Caribou Management Board, which includes an equal number of indigenous and other representatives. The Porcupine Caribou Management Agreement states objectives that its signatories cooperatively manage the Porcupine Caribou Herd and its habitat within Canada so as to ensure the conservation of the herd with a view to providing for the ongoing subsistence needs of indigenous users; to provide for participation of indigenous users in Porcupine Caribou Herd management; to protect certain priority harvesting rights in the Porcupine Caribou Herd for indigenous users, while acknowledging that other users may also share the harvest; acknowledge the rights of indigenous users; and to improve communications between governments, indigenous users, and others with regard to the management of the Porcupine Caribou Herd within Canada. The Porcupine Caribou Management Agreement states that the Porcupine Caribou Management Board is an advisory body to the Canadian federal and territorial governments, and is directed to assume responsibility for harvest allocations in the event that it determines that they are needed. With respect to the imposition of harvest quotas, a burden of proof rests with government management agencies that such actions are warranted by conservation needs.

The Porcupine Caribou Management Agreement is a single population co-management arrangement, with its jurisdictional authority limited, by the terms of the agreement, to activities in Canada. Although it has no jurisdictional authority over activities in the United States, by virtue of the subsequently signed bi-lateral U.S.–Canada Porcupine Caribou Herd agreement it is linked to the International Porcupine Caribou Board for such activities. The table (p. 646) lists various functions of the Canadian co-management, problem areas, and provisions in the Canadian Porcupine Caribou Herd agreement providing for community involvement.



Structure of the Canadian Porcupine Caribou Management Board, showing proportional representation on the board of user groups, biologists, and government agency managers.

Implications of climate change for management

While there is considerable uncertainty regarding the specific impacts of climate change on caribou and caribou hunting, it is clear that climate change is likely to affect caribou body condition, herd movements and distribution, and abundance, as well as hunters' access to hunting grounds (Berman and Kofinas, 2004; see also section 12.3.5). Given the central role of caribou in the sociocultural systems of indigenous people of the region, the negative impacts of climate change could result in significant social costs.

The capacity of a co-management regime to limit vulnerabilities and facilitate human adaptation in conditions of climate change is critical to the long-term sustainability of the system. More specifically, climate change suggests that certain functions of wildlife management may be critical in coping with possible climate change scenarios. They include:

- creating a regional forum for deliberations on caribou management issues;
- maintaining collaborative and systematic ecological monitoring;
- focusing research that draws on local and scientific knowledge;
- evaluating sensitive habitat, protecting important habitat, and participating in impact assessments;
- developing a strategic harvest management plan;
- overseeing appropriate policies for traditional barter and trade;
- guiding effective forest fire management polices and practice;
- developing climate-related communication tools; and
- achieving regional consensus and good compliance with co-management endorsed policies.

Creating a regional forum for deliberations on caribou management issues

For 17 years Porcupine Caribou Management Board members have met on caribou related issues and concerns. Meetings occur in local communities and regional centers on a rotating basis to ensure broad community input. Board-level transactions provide the basis for building relations among members who collectively represent various organizations as well as differing perspectives. Achieving consensus among the many Porcupine Caribou Herd stakeholders is rarely simple, yet the terms of the Porcupine Caribou Management Agreement and its board forum provide mechanisms for linking local, regional, and international decision-making.

The linkages in this process, however, have included problems. Western notions of efficient, representative, democratic process differ from traditional indigenous notions of consensus. Moreover, meeting agendas are often overwhelmed by discussion on policy issues, leaving little time to explore the broader implications of climate change to the region and the Porcupine Caribou Herd.

Overview of key Porcupine Caribou Management Agreement terms for community involvement (Kofinas, 1998).

Function	Problem area	Provisions guiding community involvement in various activity areas
Communication	Linking community with management	Agreement explicitly states that communities will participate and sit on board with government members. Authority for community membership is held by signatory organizations and the co-management board chair is selected by the board's membership.
Research and data collection	Adequate knowledge of caribou resource and its habitat	Agreement gives co-management board role in reviewing research and methods and encourages community members to participate in the collection of data.
Impact assessment and habitat protection	Providing a role for community to participate in the assessment of impacts and protection of habitat	Agreement includes directive to conserve resource and habitat. Also directs co-management board to participate in land management planning and impact reviews.
Policy on caribou as an exchangeable good	Exploitation of caribou resource by unchecked market forces and maintenance of traditional systems of exchange	Agreement allows for traditional systems of exchange and barter, and trade guidelines to be established to regulate those transactions. Agreement also prohibits the commercial sale of Porcupine Caribou Herd meat, but allows for the commercial sale of non-edible parts.
Enforcement	Regulations of general laws of application (e.g., safety) and hunting using traditional methods	Agreement says little about enforcement directly, but charges the board to recommend the establishment of quotas if necessary and make other recommendations to the Minister. Agreement also states that indigenous hunters can continue to harvest caribou using traditional and new methods of hunting.

In crisis conditions, however, community members and governments alike look to the Porcupine Caribou Management Board as the forum to voice concerns and engage in deliberations on management. Plus, the board's long experience with communication problems has provided time to experiment and improve its communications strategies.

Maintaining collaborative and systematic ecological monitoring

In 1996, the Porcupine Caribou Management Board in collaboration with Environment Canada, other co-management bodies and agencies of the region, various First Nations, Inuvialuit governing organizations, and local caribou users' communities recognized that climate change required a more intensive monitoring program, and created the Arctic Borderlands Ecological Knowledge Co-op. The objective of the "Knowledge Co-op" is to draw on local knowledge and science-based indicators to understand what is changing in the region and why (Kofinas et al., 2002). The focus of the monitoring is climate change, regional development, and contaminants. Interviews are conducted by local research associates each year to document local observations of unusual sightings, caribou body condition, difficulties with access to hunting grounds, caribou distribution, and movements. Findings are spatially referenced and entered into a Geographical Information System database. The findings of science and community-based monitoring are discussed at annual gatherings (see for example the Arctic Borderlands Ecological Knowledge Co-op at www.taiga.net/coop).

Focusing research that draws on local and scientific knowledge

The special problems of climate change require research by agencies and universities to link global phenomena to regional and local conditions. As a result of proposals for oil and gas development in the region, the Porcupine Caribou Herd has been the subject of intensive research and is considered the most studied caribou herd in the Arctic. Interest in climate change provides an opportunity to make comparisons with other herds, and improve overall understanding. Building on the Porcupine Caribou co-management experience, several unique research endeavors have been established involving user communities, university researchers, and agency scientists. Among them is the Sustainability of Arctic Communities project (www.taiga.net/sustain), a seven-year integrated assessment research project that has involved 22 university researchers and Porcupine Caribou Herd communities from both sides of the border (Kruse et al., 2004). This research has led to new findings on the relationships between spring green-up and calf survival, and exploration of decadal trends in timing of green-up correlating with the Arctic Oscillation (Griffith et al., 2002).

Evaluating and protecting important habitat, and participating in impact assessments

Assessment of distribution patterns of the herd during variable climatic conditions will identify sensitive habitats used by the herd. Protection of sensitive habitat maintains the resilience of the herd to endure periods of climate hardship.

The Porcupine Caribou co-management process prompted publication of the *Sensitive Habitats of the Porcupine Caribou Herd* (IPCB, 1993). Ongoing research by agencies has continued to assess at a smaller scale habitat questions and questions relating to the possible effects of changes in caribou distribution and movement due to climate change.

Planning a strategic harvest management

The potential for negative effects of climate change on the population of the Porcupine Caribou Herd suggests the need for a clear and comprehensive harvest management plan and its implications for caribou conservation and community subsistence needs. Ideally, such planning is undertaken well before there is a dramatic decrease in caribou numbers and a crisis situation occurs.

With the recent decline in population of the herd since 1989, the Porcupine Caribou Management Board has facilitated international gatherings of hunters and managers to identify thresholds at which harvest policies are necessary, and the elaborate details of those policies. To help this process, the board is using gaming scenarios with a caribou population simulation model that projects climate change conditions and serves as a discussion tool among local residents, agency managers, and managers (Kofinas et al., 2002).

Overseeing policies for traditional barter and trade

Projected population declines due to climate change may restrict harvest opportunities and create the need for greater exchange of caribou between households and between communities. Sharing and reciprocity through exchange of caribou is a traditional adaptation of subsistence hunting economies which ensures survival through periods of resource scarcity. Terms of the Canadian co-management agreement acknowledge the traditional barter and trade practices of Porcupine Caribou user communities, and direct the Porcupine Caribou Management Board to establish guidelines. Through the International Porcupine Caribou Board, interagency discussions have addressed federal government food and drug administration policies that restrict the transportation of caribou across international borders, and have come to agreement allowing the free exchange of Porcupine caribou meat between user communities across borders.

The co-management process for the Porcupine Caribou Herd brings parties of diverse interests together to discuss difficult wildlife management issues. A discussion at a special workshop on harvest management policy, held April 2002 in Inuvik, NWT, included Gwitchin hunters from Old Crow, Yukon Territory, Fort McPherson and Aklavik, NWT, Inuvialuit hunters from Aklavik and Inuvik, NWT, Iñupiaq hunters from Kaktovik, Alaska, wildlife managers from the Canadian Wildlife Service and Yukon Renewable Resources, and representatives of a Yukon sport hunters organization (photo: G. Kofinas).

Guiding effective forest fire management polices and practice

The Porcupine Caribou Management Board has worked with the Canadian Department of Indian Affairs and Northern Development (one of Canada's federal land management agencies) to map historic fire patterns across the range of the herd and to assess how the department's burn–let burn policies are sensitive to caribou habitat concerns. The board has concluded that terrain typical of the herd's winter range is so diverse, offering numerous natural firebreaks, that fires serve to maintain a healthy, uneven aged mix of habitats.

Developing climate-related communication tools

The increased uncertainty over the consequences of climate change create a demand for meaningful information exchanges between government, indigenous, private, and academic sectors. The co-management arrangement for the Porcupine Caribou Herd in Canada has pioneered several approaches to communication exchange to discuss the state of knowledge about the possible effects of climate change. These include a web-based discussion tool called "The Possible Futures Model" that simulates the combined effects of climate change, development, changes in tourism, and government spending on the Sustainability of Arctic Communities project. A more detailed explanation of the Sustainability of Arctic Communities project is provided in Chapter 12.

Achieving regional consensus and compliance with co-management endorsed policies

It can be argued that the success of co-management is best measured by the compliance of resource users and agency personnel with co-management board recommendations (Kruse et al., 1998). This measure of success recognizes that while the co-management process may facilitate new relationships among those directly involved, it is possible that miscommunications and limited support among the greater set of organizations and individuals can remain. The level of compliance of hunters to a quota due to a climate-driven decline in population is not yet known, yet there is evidence of the system's potential to enlist the support of local hunters and managers. One example is a board recommendation for a prohibition on the sale of caribou antlers, which resulted when antler buyers representing oriental medicinal markets offered to buy antlers from hunters. To date, hunter compliance with the prohibition on antler sales is high. In response to the recent decline in the herd's population, there has been a community call by Old Crow, Yukon's hunters to voluntarily (without formal policy) restrict all cow harvests.

The Porcupine Caribou Herd co-management system and climate change

Climate change is expected to be more gradual than the institutional and development-related changes of the co-management system. If the Porcupine Caribou Management

Board and its partner organizations can play the central role in monitoring, anticipating, evaluating, and responding to climate change, the board will have to maintain its legitimacy with key players that utilize the range of the herd. To be effective, the full set of groups has to feel a sense of ownership in its decision-making process. That the Porcupine Caribou Management Board has jurisdiction only in Canada may lead to a significant challenge in ensuring that a coordinated approach is taken in both countries. For that reason, there is a need for the International Porcupine Caribou Board, recently inactive because of political positions on oil development, to rejuvenate its structure and mission, and to provide the coordinated link that was intended by the international Porcupine Caribou Herd agreement.