5. Wildlife and Reindeer

Christopher A. Babcock, Department of Biology and Wildlife, University of Alaska Fairbanks

Glenn Patrick Juday, Forest Sciences Department, University of Alaska Fairbanks

David Douglas, U.S. Geological Survey, Biological Resources Division, Alaska Science Center, Anchorage

5.1 Introduction

Hunting and the consumption of wildlife are exceptionally important in Alaska. The Alaska Department of Fish and Game estimates that the average consumption of wild game by subsistence users in Alaska is 360 kg (800 lbs) per person per year. Hunting is a major activity for residents and visitors to Alaska, and the activities associated with hunting are a major source of income and economic activity. The pursuit and use of wildlife products is an important part of cultural identity for most of the Native people of the region.

Alaska is a major breeding destination for migratory birds, and Alaska sends birds to all the world's other continents. A significant proportion of world's birds use the Arctic. The Bering Sea region is a particularly productive part of the Earth's arctic region, and some of the species of animals found here do not occur elsewhere. Because Alaska has the greatest proportion of its surface area and productive resources devoted to strict nature conservation of any similar sized region in the world, it is the place where many large-bodied or wide-ranging species have their best chance of long-term survival on Earth. Alaska and the Bering Sea region are a bridge between two continents, and many wildlife species are exchanged between the continents only there.

5.2 Wildlife at Risk

Birds

The regional effects of global warming on the birdlife of Alaska are likely to be many, with influences both positive and negative on individual species, taxonomic groups, and communities. The task of predicting impacts on birds and other organisms of higher trophic status is difficult and necessarily speculative. The IPCC Scientific Assessment (Houghton et al. 1990) provides projections for change in the global and regional climate from enhanced greenhouse effect, and these have varying degrees of likelihood assigned to them dependent on model strengths and weaknesses that derive from the quality and availability of data. The first-order predictions are something in which we can be relatively confident; temperature and sea level would rise, precipitation and cloud cover would increase, growing season would lengthen, and land and sea ice would decrease both spatially and temporally. The second-order predictions about impacts to landscapes, ecosystems, communities, species, and populations are difficult to make because of our limited understanding of subjects from individual species biology through ecosystem functions. Even so, speculations can be useful in providing a framework for monitoring actual environmental change and as a way of identifying gaps in knowledge that may be vital to resolve in order to refine predictions and improve our environmental and resource decision-making.

Alaska supports relatively few winter resident bird species, especially in terrestrial ecosystems (Kessel and Gibson 1978). Much more important in terms of regional and global impact are the many migratory species that either breed in the state or pass through en route to and from their breeding grounds. All birds in Alaska would benefit to some degree from increased air temperature, as maintenance of constant body temperature is an important energetic expense, especially during nesting and the immediate post-hatch period (Myers and Lester 1992). Even marginal increases in average air temperature can lead to increased productivity through improved adult and juvenile survivorship. Additionally, lengthening of the snow-free season (Sharratt 1992) would increase production in species such as loons, swans, and raptors which take a relatively long time to reach the age of fledging. Events such as the early fall freeze-up in 1992, which led to high juvenile mortality of trumpeter swans (*Cygnus buccinator*, R. King, USFWS, personal communication), would probably become less common and/or less severe in a warmer climate. Re-nesting attempts would also be more likely to succeed with a longer growing season. Increases in precipitation are not likely to have much direct impact on birds unless they occurred as snowfall during the breeding season. Even a few degrees rise in summer temperature would not preclude the possibility of midsummer snowfall on Alaska's north slope and alpine areas. Increased frequency of storm events can have direct negative impacts that are more significant than the accumulation of minor long-term benefits of increased warmth. The lack of information about the wintering ecology of seabirds and waterfowl in the Bering Sea and Gulf of Alaska is of concern because storms may affect overwinter mortality, through both direct physiological stress and reduced food availability.

Major uncertainties remain in predictions of the magnitude and direction of climate change on wildlife as they may be controlled by community-level and ecosystem-level interactions. The patterns of plant growth and community composition will certainly change under increased temperature and carbon dioxide fertilization (Jefferies et al. 1991). Decomposition and nutrient fluxes will increase, but whether plants or soil microbes will be able to capitalize on the benefits of increased fluxes is unknown (Field et al. 1992). Grazers such as geese and swans may face reduced availability and quality of forage, as plants become nutrient limited in a carbon-rich environment and changes in plant-to-plant competition cause shifts in plant community structure. Insects, as cold-blooded herbivores, may be better able to track plant development, and their numbers may well increase to the benefit of avian insectivores (Ayres 1993). Most migratory birds use daylength cues for timing their northward movement, so that nest initiation and hatching correspond to peaks of food quality and availability. Earlier development of plants and insects relative to daylength may cause decreases in offspring survival as timing of hatching becomes uncoupled from resource availability (Myers and Lester 1992). All predictions about effects of climate change must be weighed against much less subtle anthropogenic degradations such as habitat loss, pollution, and unsustainable resource harvest (Paine 1993), both within Alaska and globally.

The expected direct effects of climate change on birds in Alaska are clear: temperature increases will generally increase survivorship through reduced exposure for adults and young during the nesting season, more benign winter temperatures will increase survival of overwintering species (Root 1993, Repasky 1991), and lengthening of the growing season will also lead to increased production, especially in those species, such as loons and swans, which have a long developmental vulnerability between hatch and fledging. Predictions of increased storm frequencies and intensities would tend to moderate the positive effects of warming and could lead to decreases in those species which are susceptible to catastrophic weather disruptions during the nesting season, migration, or in wintering aggregations. Second-order effects (influences modulated through food webs, changing nutrient availability, changes in whole plant communities, altered competition between species, and mutualisms), are generally much more difficult to predict. Such projections are derived through chains of deductive reasoning, which requires information on many aspects of the ecosystems' responses to climate change. Some of the needed inputs would include the seasonal quality and productivity of plants, seed set and fruiting, soil decomposition processes, insect population dynamics, freshwater and marine productivity and food webs, and predation pressure and sensitivity. Projections of such indirect effects require discussion on a case by case basis. It's useful to examine some major taxonomic groups and the community- and ecosystem-level changes that may affect them.

Loons: Warmer temperatures will mean increases in fresh water and nearshore marine primary productivity (Schindler et al. 1990). Increases in phytoplankton biomass will lead to increases in net productivity through the food web, including availability of small fish for freshwater birds that eat fish.

Seabirds: Much of the spring pulse of marine primary productivity in the Bering Sea appears tied to processes linked to warm currents and rapid retreat of the sea ice edge (Alexander 1992). Warming could lead to spatial and temporal unpredictability and dilution of this productivity event, with repercussions through the marine food web. Ocean surface warming trends in the North Sea are correlated with reduced production of phytoplankton, fish stocks, and seabirds (Aebischer et al. 1990).

Waterfowl: Along with a potential drop in forage quality and availability for the herbivorous members of this group, there may be long-term habitat degradation and losses with increases in sea level (especially in coastal western and northern Alaska where tectonic uplift of the land surface is much less rapid than in the southern parts of the state). Ducks would benefit from increases in numbers of insects and freshwater invertebrates.

Shorebirds: Increases in terrestrial and estuarine invertebrate food species would be likely in a warmer climate, but the increase could occur as a longer and lower amplitude period of food availability.

Raptors (birds of prey): A complex of trophic uncertainties makes it difficult to project secondary effects on top carnivores with any confidence, but general increases in ecosystem productivity should benefit raptors.

Passerines (songbirds): Insectivorous species will probably benefit from increases in insect production depending on the timing of food availability. Because plant fruiting and seed set would increase in a warmer climate, at least among plants not limited by nitrogen availability, fruit- and seed-eating birds would benefit.

Mammals

Small Mammals: Microtine rodents are an important part of many Alaskan land ecosystems. These animals account for more biomass and plant consumption per unit area on the tundra than any other vertebrate herbivore (Batzli et al. 1980). Even though caribou and waterfowl may be prominent herbivores in restricted locations and for comparatively short periods, microtines are active herbivores year round. Microtine rodents of the tundra show large periodic increases in population density (Krebs et al. 1973), and these increases affect the tundra environment by intense and destructive plant consumption (Batzli 1975) and increased densities of microtine predators (MacLean et al. 1974).

Most small mammals are active throughout the winter, consuming frozen green plant material in the space between the snow and ground surface. Sufficient snow depth to adequately insulate the subnivean space is crucial for the energetic balance, and therefore overwinter survival, of small mammals (Pruitt 1984). Decreases in snowfall would therefore negatively impact small mammal populations. Snow surface icing events also lead to increased mortality by causing CO_2 build-up (because this gas does not readily diffuse through ice). Recent results from studies on the North Slope show that experimental warming of tundra leads to increases in dwarf shrubs and decreases in formerly dominant grasses and sedges (Chapin and Shaver 1996). The decrease in grasses and sedges appears to be caused by increased grazing by microtine rodents, which benefit from increased shrub cover in avoiding avian predators (F.S. Chapin, personal communication).

Caribou: Caribou (*Rangifer tarandus*) are the dominant large herbivore of tundra ecosystems and an important economic and cultural resource of northern indigenous peoples. Accelerated climate-induced changes to the temporal availability, quality, and composition of forage resources will likely alter caribou distributions and population dynamics. Several potential effects of global warming can be individually projected, but the complexity of integrating these prevents us from making general conclusions about arctic caribou populations as a whole. Even without considering the long-term implications of landscape-level changes to the vegetative composition of the arctic tundra, global warming could impose both positive and negative effects on caribou populations in the near future.

Greater amounts of winter precipitation falling as snow would make winter foraging (cratering) more difficult, potentially reducing the carrying capacity of areas that caribou presently used as winter range. Warmer conditions could also increase the frequency of autumn or winter ice storms (freezing rain) which can effectively render forage plants unavailable and result in mass starvation. Warmer temperatures during summer could increase the frequency and intensity of harassment by biting insects, such as mosquitoes and warble flies, which diminishes the amount of time caribou can spend foraging, thereby potentially reducing body-fat reserves for over-winter survival. Finally, a warmer climate may create favorable conditions for invasion by exotic parasites or diseases.

Conversely, earlier snow melt and onset of the vegetation growing season would create improved foraging conditions for pregnant cows who are entering the energetically costly period of lactation. Increased quantity and quality of forage intake would allow a lactating cow to provide more energy and nutrients to growth of her calf, increasing calf weight gain and enhancing calf survival. Longer arctic growing seasons could also increase overall summer nutritional intake and increase the probability of cows attaining sufficient weight and fat reserves for subsequent conception and ultimate population growth of the herd. The integrated effects of global warming on caribou populations are expected to vary regionally, depending on future patterns of regional climate trends and anomalies which are poorly understood at this time, as well as the demographics and ecology of the respective regional herds. In the near future, global warming does not pose a threat of extinction to caribou, but the economic and cultural importance of the species requires a greater understanding of the direction, rate, and magnitude of future changes so that management of the species can be proactive.

Reindeer: Reindeer production is an important economic pursuit for Alaska Natives on the Seward Peninsula and has many desirable attributes as a sustainable resource production system. Reindeer grazing harvests natural vegetation efficiently without drastically modifying it. Markets for Alaska reindeer products are established and have expanded in recent years, although foreign competition has increased. Reindeer herding allows Alaska Natives a cash- and food-producing livelihood that uses many traditional skills and knowledge of the land.

Reindeer production in Alaska was reserved by law to Alaska Natives until a recent court decision and is concentrated almost exclusively on the Seward Peninsula, where reindeer have been tended for over a century. Reindeer herding on the Seward Peninsula has characteristics of both a subsistence activity and a modern animal product industry. The reindeer industry depends on natural, social, and economic factors for its existence, and a significant alteration in any one of these three factors may cause problems for the industry and the herding way of life.

The Seward Peninsula reindeer production system allows animals to range freely for most of the year, with annual roundups for harvest of antlers, herd census, culling, and veterinary attention. Reindeer numbers are known only approximately and vary over the short term, but in the mid-1990s the herd totaled about 20,000 animals on the Seward Peninsula. The tundra forage that supports reindeer was in excellent condition on the Seward Peninsula in the mid- and late 1990s.

Five recent or potential challenges to the health or survival of the industry are related to global change: (1) ice-coating of winter forage, (2) poor-quality forage in warm and dry summers, (3) caribou range expansion and capture of reindeer, (4) tundra fires, (5) forest expansion into tundra.

Ice-coating of winter forage:

During the winter, reindeer depend on access to range that is rich in lichens. The lichens provide almost exclusively carbohydrates as a source of energy to maintain body temperature in the winter. Reindeer can effectively paw through snow to reach lichens in the winter. Generally, temperatures are well below freezing in the fall when the first snow coats the Seward Peninsula, but occasionally in warmer years a freezing rain coats lichens and other tundra plants with a layer of ice. The ice cover makes forage critical to reindeer survival essentially unavailable for the entire winter. Such an event occurred on the Chukotka Peninsula in eastern Russia in the fall of 1996, leading to the death of thousands of reindeer. Freezing rain events are much more likely in a warming climate on the Seward Peninsula. Recent freezing rain/ice coating events occurred on Hagemeister and Nunivak Islands.

Poor-quality forage in warm and dry summers:

Reindeer obtain most of their annual budget of nitrogen, which is vital for protein replenishment to build muscle mass and skeletal tissue, during a short period in early summer. Reindeer get nitrogen from succulent early summer forage plants which mature slowly in the typically cool and moist weather of the Seward Peninsula summer. However, in years with warm and dry summer weather forage plants mature quickly and become fibrous with low nitrogen content. A diet of plants that are too fibrous nutritionally stresses reindeer and caribou because they are limited in when they can obtain their required nitrogen reserves. A succession of warm and dry summers will first severely stress reindeer nutritionally, and if warmer weather persists, cause displacement of palatable tundra forage species by indigestible shrubs and eventually trees. Sustained warmer summers would dry out the tundra and organic soils it grows on, leading to a greater risk of tundra fire. Lichens grow slowly and so are slow to recolonize burned areas.

Caribou range expansion and capture of reindeer:

Tens of thousands of wild caribou moved into wintering areas occupied by reindeer in the Kivalik and Buckland Valleys in the winter of 1996-97. Caribou are North American native members of the same species as reindeer. Once caribou and reindeer mix together a substantial portion of the reindeer may follow the caribou to their summer use areas far removed from the reindeer herding region. Reindeer that join caribou herds are essentially lost. Another undesirable consequence of the mixing is potential cross-breeding and the introduction of non-native genes into the Alaska wild populations.

Tundra fires:

Tundra is generally resistant to burning, but prolonged periods of above normal temperatures and below normal precipitation make the tundra capable of carrying fire across the landscape. Tundra vegetation, especially lichens, can be very slow to recover following fire. Lichens are the key vegetation for winter grazing by reindeer and caribou as a carbohydrate-rich source of energy. During the long recovery period following a fire in lichen-rich tundra, the carrying capacity for reindeer and caribou is considerably diminished.

During the summer of 1977 several lightning-caused fires burned across large areas of tundra on the Seward Peninsula (Racine 1979). One fire northeast of Imuruk Lake covered 96,000 ha (236,000 ac), and the total area burned was 359,000 ha (887,000 ac). Climate warming and drying on the Seward Peninsula would produce more frequent and prolonged conditions favorable for burning.

Forest expansion into tundra:

In Alaska the limit of tree growth is influenced to a large degree by mountains - the Brooks Range in the north effectively separates arctic tundra from boreal forest. Even significant amounts of climate warming would primarily result in relatively narrow bands of elevational expansion of forest vegetation. The Seward Peninsula is unusual in that it offers relatively modest topographic barriers to tree growth, and should the climate warm sufficiently, a considerable land surface area of tundra would be converted to forest. The current cool moist summer and relatively mild winter climate of the Seward Peninsula supports a relatively productive form of treeless tundra. A conversion of the Seward Peninsula from tundra to forest vegetation would result in dramatically decrease d production of palatable forage species for reindeer. Any significant expansion of forest into the productive tundra of the Seward Peninsula would represent a significant negative factor for reindeer production.

5.3 Future Changes

The major currently foreseeable changes in Alaska wildlife resources from projected climate warming include the following:

- A potential mismatch in the timing of important seasonal events such as spring snowmelt or the development of green vegetation and the arrival or movement of wildlife that depend on these critical events could significantly decrease wildlife productivity.
- Longer growing seasons would improve survival and productivity of some species.
- Changes in latitudinal species distributions would occur due to changes in habitat, generally involving northward movement, especially of mammals.
- Changes in insect numbers, including increased insect harassment of large animals such as caribou and possible appearance of ticks, could lead to new problems for important harvested species.
- Potential changes in migration routes might occur.
- Extreme weather events, such as storms and droughts, would become more common, often reducing wildlife productivity on a short-term basis.
- In Alaska forests, increased insect damage to trees and logging would reduce the extent of older forest habitats and cause population declines of wildlife that depend on them.
- An increase in the extent of productive early successional habitat and wildlife that can use would follow after extensive disturbance of forest and other vegetation by insects and fire.
- Warmer climates would cause upward movement in elevational distribution of vegetation and wildlife, leading to increased competition or local extinction of a few high elevation species.
- Extensive thawing of discontinuous permafrost accompanied by ground subsidence would increase the extent of wetland habitat.
- A change in the composition of boreal forest, resulting in decreased extent of spruce and increased total area of aspen and other hardwoods, would favor certain birds and browsing mammals and reduce birds, flying squirrels, and other species that depend on or are favored by conifer forests.
- A warmer climate would probably allow the spread of diseases, especially diseases of domestic animals, that currently do not occur in Alaska.

Any changes to wildlife caused by climate change must be understood against the backdrop of human natural resource management practices, such as hunting or forest management, that are often the major influence on wildlife productivity and distribution. Wildlife responses are a product of both climate variability and human resource practices. Particularly acute situations caused by either climate or human influences can increase wildlife sensitivity to the other. For example, a wildlife population at a low level because of heavy human consumption may be less able to persist or remain productive under the stress of an altered climate. Similarly, a wildlife population that has been reduced because of climate variability may not be able to withstand the same degree of habitat modification as if it were healthy.

Because global warming models based on greenhouse gases indicate that the earliest effects and the greatest rate and magnitude of temperature change is expected in Alaska compared to the rest of the United States, Alaska's wildlife may face special challenges. But two factors suggest that the prospects for wildlife in Alaska are good in the long term. First, Alaska has a history of abrupt changes in temperature, so a certain degree of adaptability of the wildlife and ecosystems is probably present as a result of these past events. Second, intactness of ecosystems is thought to provide a certain amount of resilience and recovery potential, so the fact that a larger proportion of Alaska is conserved in national-level reserves than anywhere else in the world provides some of the most effective mitigation of climate change effects to be found anywhere.

In summary, this report provides a limited overview of some possible repercussions of regional warming for Alaska terrestrial birds and mammals. Several of the above speculations about climate change effects are debatable, and they should not be regarded as predictions but rather as working hypotheses, best resolved with increased study and successive refinements in our knowledge of northern ecosystems. While overall prospects for Alaska's wildlife are good, local wildlife problems could easily become serious, both for people who wish to harvest or simply view Alaska's wildlife, and for the health of affected wildlife populations themselves.

5.4 Additional research needed

- Establish quantified linkages among regional-scale climate, vegetation phenology, forage quality, and caribou population dynamics.
- Monitor latitudinal incidences of ungulate diseases and parasites.
- Study the interaction of caribou and reindeer including factors that attract caribou into reindeer ranges and behavioral factors that combine or segregate reindeer and caribou.
- Study reindeer management and herding practices that are effective in sustaining herds in the face of climate change.

5.5 Mitigation and adaptation measures

- Put in place integrated wildlife monitoring programs that will provide the earliest possible warning of major changes in the status of wildlife populations so that short- and long-term management measures can be developed or applied and unnecessary stresses from human influences can be avoided.
- Adjust either wildland fire suppression or prescribed fire to reflect wildlife habitat needs on a regional basis in the light of altered climates.
- Develop a set of adaptive sport-harvest and subsistence management plans that accommodate a variety of potential climate-induced changes to caribou distributions and abundance.

- Develop an effective policy for caribou management on the border of reindeer grazing zones.
- Develop an emergency response plan to move reindeer from areas affected by ice coated vegetation to ice-free areas and/or emergency herd reduction or salvage measures in climatic emergencies.
- Develop better reindeer storage and handling infrastructure.
- Apply range management practices that favor tundra and retard shrub and tree development, especially on the eastern Seward Peninsula reindeer grazing regions.

5.6 Bibliography

Aebischer, N.J., J.C. Coulson, J.M. Colebrook. 1990. Parallel long-term trends across four marine trophic levels and weather. Nature 347:753-755.

Alexander, V. 1992. Arctic marine ecosystems. Pages 221-232 *in* R.L. Peters, T.E. Lovejoy (eds.) Global Warming and Biological Diversity. Yale Univ. Press. New Haven, Conn.

Ayres, M.P. 1993. Plant defense, herbivory, and climate change. Pages 75-94 *in* P.M. Kareiva, J.G. Kingsolver, R.B. Huey (eds.) Biotic Interactions and Global Change. Sinauer Associates. Sunderland, Mass.

Batzli, G.O. 1975. The role of small mammals in arctic ecosystems. Pages 243-268 *in* F. Golley, K. Petrusewicz, and L. Ryszkowski (eds.) Small mammals: their productivity and population dynamics. IBP. Cambridge Univ. Press, Cambridge 5:1-451.

Batzli, G.O., R.G. White, S.F. MacLean Jr., F.A. Pitelka, and B.D. Collier. 1980. The herbivore-based trophic system. Pages 335-410 *in* J. Brown, P.C. Miller, L.L. Tieszen, and F.L. Bunnell (eds.) An arctic ecosystem: the coastal plain of northern Alaska. Dowden, Hutchinson, and Ross, Stroudsburg, PA.

Chapin, F.S. III, and G.R. Shaver. 1996. Physiological and growth responses of arctic plants to a field experiment simulating climatic change. Ecology 73:822-840.

Field, C.B., F.S. Chapin III, P.A. Matson, H.A. Mooney. 1992. Responses of terrestrial ecosystems to the changing atmosphere: A resource-based approach. Annual. Rev. Ecology and Systematics 23:201-235.

Houghton, J.T., G.J. Jenkins, and J.J. Ephraums (eds.). 1990. Climate Change: The IPCC Assessment. Cambridge Univ. Press. Cambridge.

Jefferies, R.L., J. Svoboda, G. Henry, M. Raillard R. Reuss. 1991. Tundra grazing systems and climate change. Pages 391-412 *in* F.S. Chapin III, R.L. Jefferies, J.F. Reynolds, G.R. Shaver, and J. Svoboda (eds.) Arctic Ecosystems in a Changing Climate: An Ecophysiological Perspective. Academic Press. San Diego, Calif.

Kessel, B., and D.D. Gibson. 1978. Status and Distribution of Alaska Birds. Studies in Avian Biology, Cooper Ornithological Society.

Krebs, C.J., M.S. Gaines, B.L. Keller, J.H. Myers, and R.H. Tamarin. 1973. Population cycles in small rodents. Science 179:35-41.

MacLean, S.F. Jr., B.M. Fitzgerald, and F.A. Pitelka. 1974. Population cycles in arctic lemmings: Winter reproduction and predation by weasels. Arctic and Alpine Research 6:1-12.

Myers, J.P., R.T. Lester. 1992. Double jeopardy for migrating animals: Multiple hits and resource asynchrony. Pages 193-200 *in* R.L. Peters, and T.E. Lovejoy (eds.) Global Warming and Biological Diversity. Yale Univ. Press. New Haven, Conn.

Paine, R.T. 1993. A salty and salutary Perspective on global change. Pages 347-355 *in* P.M. Kareiva, J.G. Kingsolver, and R.B. Huey (eds.) Biotic Interactions and Global Change. Sinauer Associates. Sunderland, Mass.

Pruitt, W.O. Jr. 1984. Winter ecology of small mammals. Special Publications of the Carnegie Museum of Natural History, Number 10. Pp 1-8.

Repasky, R.P. 1991. Temperature and the northern distributions of wintering birds. Ecology 72:2274-2285.

Root, T.L. 1993. Effects of global climate change on North American birds and their communities. Pages 280-292 *in* P.M. Kareiva, J.G. Kingsolver, and R.B. Huey (eds.) Biotic Interactions and Global Change. Sinauer Associates. Sunderland, Mass.

Schindler, D.W., K.G. Beatty, E.J. Fee, D.R. Cruikshank, E.R. DeBruyn, D.L. Findlay, G.A. Linsey, J.A. Shearer, M.P. Stainton, and M.A. Turner. 1990. Effects of climate warming on lakes of the central boreal forest. Science 250:967-970.

Sharratt, B.S. 1992. Growing season trends in the Alaskan climate record. Arctic 45:124-127.