IV. Challenges for Wildlife and Fish Conservation

Not surprisingly, Alaska's wildlife managers face some formidable odds as we work to maintain the state's wealth of wildlife, prevent species from becoming listed as threatened or endangered, and keep common species common. Some of the challenges we face are unique to our geographic location, the dynamic landscape around us, and our lack of information and analytical tools. Others are common challenges that all jurisdictions face in protecting and conserving their natural biotic communities; these include minimizing impacts of needed development and properly managing existing conservation lands in the face of an increasing population of human users and limited fiscal resources.

All of these challenges factored heavily into the types of conservation actions experts believe would be effective in better conserving Alaska's wealth of wildlife. The specific conservation action plans that experts created for dozens of featured species and species groups are addressed in Section V (Conservation Action Plans), and relative priorities of conservation effort are addressed in Section VII (Primary Recommendations: Alaska's Greatest Wildlife Conservation Needs).

A. The Changing Natural World

Climate Change

At a time when the human population and demand for natural resources development are both expanding, so is the need to document, understand, and maintain the diversity of fish and wildlife species. For Alaska, this task will be complicated by the substantial biological response of natural systems to the climate changes expected here. Some physical changes Alaska is experiencing, such as rising average temperatures, thinning sea ice, and changing ocean circulation patterns, have been building or underway for at least a couple of decades (Anderson and Weller 1996). However, according to a newly released report described below, the Arctic—especially Alaska and the Canadian Yukon—is now experiencing some of the most rapid and severe climate change on Earth, and this trend is expected to accelerate over the next century.

Arctic Climate Impact Assessment (ACIA) Report

In November 2004, two working groups of the Arctic Council (Conservation of Arctic Flora and Fauna [CAFF]) and Arctic Monitoring and Assessment Programme [AMAP]), in conjunction with the International Arctic Science Committee, released a comprehensive assessment of the causes and consequences of climate change in the Arctic. Titled "Impacts of a Warming Arctic: Arctic Climate Impact Assessment," this 139-page summary document took four years to prepare and involved more than 300 scientists from the United States, Canada, Finland, Greenland, Iceland, Norway, Russia, and Sweden, as well as indigenous peoples' leaders in all eight countries.

Each country defines “Arctic” slightly differently: In Alaska, the Arctic boundary roughly corresponds to present-day treeline from about McNeil River on the west side of Cook Inlet, south to Kodiak and Afognak Islands, westward to the Aleutian Islands, then north and eastward to the Canadian border, together with the associated marine waters. To view a map, see: http://www.caff.is/sidur/sidur.asp?id=2&menu=about.

The ACIA report contains informative graphics and photos and specific examples illustrating climate change impacts in Arctic countries. The phenomena described include rising temperatures, river flows, and sea level; melting ice sheets and glaciers; thawing permafrost; increasing precipitation; declining snow cover; diminishing lake and river ice; changes in ocean salinity and circulation patterns; and retreating summer sea ice.

Significantly, the report describes projected impacts based on a moderate, not worst case, scenario of future warming. Even so, the changes it describes for the Arctic will be dramatic, contributing to major physical, ecological, social and economic impacts in Alaska and elsewhere.

Selected Key Findings: Effects on Alaska Wildlife and Users

The ACIA report’s Executive Summary lists 10 key findings. Five findings (and selected bullets) pertaining directly to wildlife and fish, their habitats, and users of these species are provided verbatim below. These are followed by a discussion of anticipated effects in Alaska and neighboring parts of Arctic Canada. For the full text of the ACIA report, go to: http://www.amap.no/acia/.

Key Finding #1: Arctic climate is now warming rapidly and much larger changes are projected.

- Annual average arctic temperature has increased at almost twice the rate as that of the rest of the world over the past few decades, with some variations across the region.
- Increasing global concentrations of carbon dioxide and other greenhouse gases are projected to contribute to additional arctic warming of about 4–7 degrees Centigrade [10–18 degrees Fahrenheit] over the next 100 years.
- Increasing precipitation, shorter and warmer winters, and substantial decreases in snow cover and ice cover are among the projected changes that are very likely to persist for centuries.

Key Finding #2: Arctic warming and its consequences have worldwide implications.

- Increases in glacial melt and river runoff add more freshwater to the ocean, raising global sea level and possibly slowing the ocean circulation that brings heat from the tropics to the poles, affecting global and regional climate.
- Impacts of arctic climate change will have implications for biodiversity around the world because migratory species depend on breeding and feeding grounds in the Arctic.

Key Finding #3: Arctic vegetation zones are very likely to shift, causing wide-ranging impacts.

- Treeline is expected to move northward and to higher elevations, with forests replacing a significant fraction of existing tundra, and tundra vegetation moving into polar deserts.
- Disturbances such as insect outbreaks and forest fires are very likely to increase in frequency, severity, and duration, facilitating invasions by non-native species.

Key Finding #4: Animal species' diversity, ranges, and distribution will change.

- Reductions in sea ice will drastically shrink marine habitat for polar bears, ice-inhabiting seals, and some seabirds, pushing some species toward extinction.
- Caribou/reindeer and other land animals are likely to be increasingly stressed as climate change alters their access to food sources, breeding grounds, and historic migration routes.
- Species ranges are projected to shift northward on both land and sea, bringing new species into the Arctic while severely limiting some species currently present.

Key Finding #8: Indigenous communities are facing major economic and cultural impacts.

- Many Indigenous Peoples depend on hunting polar bear, walrus, seals, and caribou, herding reindeer, fishing, and gathering, not only for food and to support the local economy, but also as the basis for cultural and social identity.
- Changes in species' ranges and availability, access to these species, a perceived reduction in weather predictability, and travel safety in changing ice and weather conditions present serious challenges to human health and food security, and possibly even the survival of some cultures.
- Indigenous knowledge and observations provide an important source of information about climate change. This knowledge, consistent with

complementary information from scientific research, indicates that substantial changes have already occurred.

Not all regions of the Arctic will experience the same effects due to climate change; changes in certain regions will be more severe than in others. Although scientists have been documenting increased air temperatures over most of the Arctic (exceptions are eastern North America and Greenland), Alaska and the Canadian Yukon are particular “hot spots,” showing the greatest average increase in temperature of any areas in the Arctic: According to the Alaska Climate Research Center, average temperatures in the state rose 3.3 degrees Fahrenheit between 1949 and 2003 (Rozell 2005).

Not surprisingly, ACIA identifies the subregion containing Alaska, Chukotka, the Western Canadian Arctic, and adjacent seas as the area where biological diversity in the Arctic is most at risk from climate change. One reason is that this quadrant is home to the highest number of threatened species, many of which are plants.

Like the ACIA authors, experts in the CWCS planning process are concerned about the likelihood of significant declines in plant and animal species over coming decades. This includes species very specifically adapted to the Arctic climate (e.g., various species of lichens, mosses, voles, and lemmings; and predators, such as Arctic fox and Snowy Owl).

Some of the greatest concern is for species that depend on sea ice for one or more critical stages of their life history (e.g., polar bear, walrus, and four species of ice seal). Models have shown that sea ice thickness has decreased by 40 percent during the past 30 years, and the average annual extent of ice coverage in the polar region has diminished substantially, with an average annual reduction of over 1 million square kilometers. Scientists now expect that radical seasonal retreats and overall thinning of sea ice will cause the marine mammals (e.g., ringed seals) on which many indigenous cultures depend to decline, become less accessible, or possibly go extinct in the next century (NOAA website: www.beringclimate.noaa.gov).

Polar bear USFWS

Experts expect sea ice reductions to cause circulation and salinity changes that could provide advantages for some species and harm others. The ACIA report mentions Beaufort Sea research suggesting that the increasing layer of meltwater now found beneath multiyear ice may already have profoundly affected species of ice algae that form the base of the marine food web. The report contains an excellent illustration of the complex trophic relationships among ice-edge and marine plants, fish, birds, and mammals.

Coastal non-Arctic species may also be hard hit—due to melting of glaciers, both near the coast and well inland. Experts have been astounded at the rapid rate of glacial thinning and retreat in Alaska in recent decades. The ACIA report estimates that the projected contribution to global sea level rise by melting glaciers in Alaska is nearly double that of the Greenland Ice Sheet during the past 15 years. Ongoing sea level rise due to melting glaciers, and inundation of low-lying coastal areas, such as the Yukon-Kuskokwim Delta, may alter intertidal areas and harm invertebrate prey species populations important to migratory shorebirds, many of which are of national and international importance.

Other species likely to see significant ice melt-related effects are the species and species groups narrowly adapted to periglacial environments (e.g., Myctophids, a marine fish group; and Kittlitz' murrelets). As marine glaciers retreat inland, the sea-and-ice interface habitats required by these species disappear.

Destruction of ground surface and vegetation due to thawing of ice-rich permafrost and thermokarst formation, near Fairbanks.
V. Romanovsky, Geophysical Institute, UAF

Experts also expect Alaska's terrestrial landscapes and natural vegetative communities to be significantly altered. Alaska has more than 175 million acres of wetlands covering approximately 43% of the surface area of the state. Melting of permafrost beneath vast expanses of wetlands will alter hydrological flows and drainage patterns within and adjacent to wetland systems.

Mature old-growth forests are experiencing other forms of climate-related disturbance and loss, including increased occurrence of insect outbreaks and wildfire. Alaska's Kenai Peninsula and Canada's Tatshenshini and Kluane Lake areas have undergone historic levels of infestation and forest decimation by spruce bark beetles in the past decade. The numbers, acreage, and intensity (e.g., destructiveness to soils) of Interior Alaska forest fires have also increased. One ACIA projection suggests that, as a result of climate change, we can expect a threefold increase in total area burned per decade, with loss of coniferous forests eventually leading to a deciduous forest-dominated landscape, including on the Seward Peninsula, an area currently dominated by tundra.

Participants in the CWCS experts' meetings noted that a warming climate may benefit the distribution and/or abundance of some species currently at the edge of their range (e.g., trout-perch, which thrives in milder climates). Others expressed concern that climate change may increase the threat Alaska already faces from opportunistic nonnative species, such as Atlantic salmon (*Salmo salar*) and the

European green crab (*Carcinus maenas*), both of which are invasive species on the west coast of North America. However, they recognized that what is one day considered a nonindigenous or invasive (i.e., *harmful* nonindigenous) species may ultimately become a valued replacement for other species whose ranges shift farther northward. For more information on concerns with nonindigenous and invasive species, see Section IV(C), under "Introduced, Nonindigenous, and Invasive Species."

Projected to persist for centuries, the climate change affecting Alaska is likely to have significant impacts on the distribution and abundance of many species, especially those narrowly adapted to their environment or otherwise at risk (e.g., from human disturbance, such as oil spills and habitat fragmentation). Over time, we can also expect to see climate-related shifts in the timing and location of key events we associate with harvest opportunity, such as diurnal movements and seasonal migration.

Physical access to many species may also be affected. Due to thinning and loss of sea ice, Native elders report that hunting of marine mammals is noticeably more dangerous and less productive today than in the past. People in pursuit of other species also face increased travel difficulties over time, e.g., as tundra areas become covered in chest-high brush, and as thawing of permafrost degrades and alters existing travel routes and infrastructure.

Tectonic and Isostatic Uplift

Alaska is located on the seismically active north Pacific rim, where expanding plates of the Earth's crust collide and descend below the North American continent. The pressures this creates are released in the form of volcanic and earthquake activity. With the exception of the Wrangell volcanoes and Mt. Edgecumbe in Southeast Alaska, most of the state's active volcanoes occur in an arc that includes the entire Aleutian Island chain eastward to Mt. Spurr, opposite Anchorage. Volcanic activity can cause sudden, cataclysmic change in surrounding ecosystems. However, subsidence and uplift of the earth's surface due to earthquakes and deglaciation probably has a greater overall effect on the abundance, diversity, and distribution of fish and wildlife.

In addition to causing earth tremors, differential slippage of tectonic plates along geologic faults often results in vertical and horizontal displacements of the earth's crust. During an earthquake, wide swaths of terrestrial or benthic habitat can suddenly be jolted to a different elevation, causing displacement or loss of the wildlife populations and habitat types that had been present.

The Great Alaska Earthquake of 1964 (Richter magnitude of 9.2) caused notable changes in land level over an estimated 70,000 to 110,000 square miles (180,000 to 285,000 square kilometers), much of it on and adjacent to the continental shelf. Five-mile long Middleton Island, located 160 miles southeast of Anchorage in the Gulf of

Alaska, rose by 12 feet and gained more than 1,000 acres of shoreline—a boon to ground-nesting shorebird populations, but devastating for cliff-nesting seabirds such as kittiwakes, whose chicks could no longer flutter directly into the ocean.
Uplift measurements along the coast of the Gulf of Alaska averaged 6 feet (1.8 meters), with elevation gain on the seafloor adjacent to Montague Island recorded as 38 feet (11.5 meters), but estimated to have been as much as 50 feet (15.25 meters) in places. Such large changes in seafloor elevation would have significantly altered the composition of benthic communities if it caused uplift into, or subsidence out of, the photic zone (ocean depths penetrated by light).

The degree of subsidence in the affected region was less, averaging 2.5 feet (0.75 meter). A maximum subsidence of 7.5 feet (2.25 meters) was measured along the southwest coast of the Kenai Peninsula (Alaskool website). Evidence of subsidence can easily be seen from the highway at the south end of Turnagain Arm, in the form of standing dead trees—the remnants of forests killed by an altered tidal regime.

During the 1964 earthquake, Prince William Sound experienced both vertical and horizontal shifts along some sections of the coast. These changes are believed to have caused many formerly anadromous streams and stream reaches to shift course and/or become impassable to upstream migrants, limiting the range of some fish stocks.

A change in substrate elevation can occur rapidly, as in an earthquake event, or more gradually, e.g., through isostatic uplift. This term refers to the gradual elevation rise that occurs as land is relieved of the weight of retreating glaciers. This process is occurring in many places around the state, including in and around Glacier Bay National Park. At nearby Gustavus, 3,210 acres of former tidelands were recently purchased by a coalition of private interests including The Nature Conservancy. Of that amount, 1,439 acres were donated to the State of Alaska for eventual expansion of the Dude Creek Critical Habitat Area, the largest expanse of undisturbed wet meadow habitat in the region and a key resting area for migrating Lesser Sandhill Cranes.

Not far away, the Mendenhall Wetlands State Game Refuge in Juneau is experiencing an uplift rate of about 0.6 inches per year (Hick and Shofnos 1965, cited in Armstrong et al. 2004). Recent surveys show that composition and location of key vegetation types, and bird species' distribution on the refuge, are changing as a result. In many places, "high marsh" complexes dominated by grass species have replaced the sedge-dominated low marsh communities. Migrating Pipits and Longspurs favor the former, while the latter is nutritionally critical for waterfowl such as Vancouver Canada Geese, which graze on sedge sprouts in the spring and sedge seeds in fall (Armstrong et al. 2004). Habitat succession and use studies can help identify areas important for wildlife resources.

Ongoing climatic change, tectonic shifts, and isostatic uplift highlight three important conservation and management needs for Alaska. These are to: 1) assess species distribution, abundance, and habitat use, and the potential impacts to wildlife from climate and tectonic change; 2) institute robust long-term monitoring programs to document baseline and changing conditions for species, species assemblages and ecosystems; and 3) build capacity in terms of data management, mapping, and GIS tools available to assist fish and wildlife managers, as well as development interests.

Other needs are to identify and better manage key habitats, including existing conservation units used by poorly known and at-risk species, and to educate the public about observed or predicted changes in wildlife populations and their habitats. Together with these needs come unique opportunities. For example, by placing informative time-series photo displays along roadsides and trails, Alaska could market itself not only for its wildlife values but also as a fascinating and accessible laboratory on tectonic climate change.

Wildfire

Fire is a natural phenomenon affecting the Alaskan landscape. Across the state, lightning starts approximately 200 fires per year, and human actions cause about 400 more. Historically, the natural fire cycle of Interior Alaska has burned 1.5 million–2.5 million acres each year, or about 1 percent of the landscape. However, as noted above in the ACIA report’s Key Finding #3, the frequency, severity, and duration of forest fires in the state are expected to increase.

Periodic wildfires generally benefit wildlife. Because wildfires typically burn erratically, they leave a patchwork of vegetation across the landscape. This mosaic pattern is the key to habitat diversity because it maintains multiple stages of forest succession. Some species thrive in the new growth that comes after a fire, while others need the patches of older unburned forest that are left standing after a typical wildfire. Some species use both types of habitats, but need them at different times of the year or for different life stages.

Mosaic pattern in vegetation after wildfire
BLM, Alaska Fire Service

Although many animals can escape fire by fleeing or by hiding underground, some die when the forest burns. Those that remain usually thrive in the years and decades after a fire. For instance, the black-backed woodpecker moves into recent burn areas, where it eats bark beetles that invade the dead and dying trees. Major historic fires have created unparalleled improvements in habitat for moose and bison. Periodic fires also provide benefits by clearing fuel and creating natural fire breaks, thus reducing the risk of more intense, damaging fires.

Land managers sometimes try to simulate wildland fires through prescribed burns. This is occasionally used as a management tool to enhance wildlife habitat. At other times, the intent is to manage forest fuels, thus helping to prevent more intense and potentially dangerous fires, especially around areas inhabited or otherwise valued by humans.

Despite the potential benefits of wildfire, many fires in the state are purposely extinguished because of concern for human safety, private property, and commercial timber. While concerns for human safety and private property must always come first, not allowing wildfires to burn can cause unnatural aging of the forest and loss of the typical habitat mosaic and associated wildlife species that previously occupied the area.

Vulnerability of Species with Restricted or Limited Distributions

Natural changes and other factors can cause a species to have a limited distribution within an area or within the state. Similarly, a species may have a limited distribution year-round or during a particular season, such as the breeding season.

Spatially and temporally restricted species are generally considered more susceptible to threats and more vulnerable to extirpation and extinction than species that are common and broadly distributed. Unpredictable events are much more likely to have a critical impact on a species when a large proportion of the population is concentrated in a few locations. Species with restricted ranges may be catastrophically affected by predictable or random threats such as:

- changes in climate (extreme weather, severe storms, flooding, temperature regime shift);
- natural disasters (wildfires, earthquakes, volcanoes, tsunamis);
- industrial contamination (oil spills, toxic discharges, pesticides);
- introduction of exotic predators or competitors;
- changes in interspecific interactions and trophic relationships (predation, competition, disease, trophic regime shift);
- human overuse (unsustainable harvest and poaching);
- natural or human-related habitat alteration and loss.

A number of factors may exacerbate the vulnerability of species with limited distributions. Small population size, low reproductive potential, slow rates of population growth, long generation time, highly variable or cyclic populations, poor dispersal or colonization capacity, and narrow niche specialization all contribute to the susceptibility of a species to extirpation and extinction.

Both spatial and temporal elements must be considered when evaluating any species' range and vulnerability. Some species, such as island endemics and so-called "sky island" (i.e., mountain top-restricted) species, have a generally limited spatial distribution: The entire population is always concentrated in a limited space. For other species, the restriction in range may only occur at specific times during their life cycle, as is the case for most migratory and colonial breeding species.

The conservation of species with restricted ranges depends on the protection of key habitats and the management of potentially deleterious human activities at those times and locations a species is most vulnerable. Due to the general paucity of available information, survey, inventory, and monitoring efforts are vital in Alaska to define the distribution and abundance of a vast number of species and assessing their vulnerability. In many instances, research will be necessary to elucidate the likely or potential threats facing a species during each life stage (e.g., breeding, rearing, nesting, refugia).

B. Lack of Shared Information and Understanding

Natural phenomena, many of them largely out of human control, pose unique challenges for Alaska's wildlife managers. Other challenges result from the size and remoteness of the state, coupled with the expense and logistical difficulties of conducting inventory, research, or monitoring efforts.

Fish sampling using beach seine
F. DeCicco, ADF&G

While there are many good examples of existing data and information sharing, this section was developed to look at the difficulties we face from lack of information about species and habitat associations. We encourage incorporation of existing traditional and local user knowledge into Alaska's toolbox for species conservation. This section describes our lack of spatial data and data management systems and provides suggestions for addressing some major needs. It ends with a discussion of the substantial conservation benefits to be gained through targeted education and outreach efforts to Alaskan residents and visitors.

Lack of Information about Species or Habitats

A serious impediment to the goal of better conserving broad arrays of species is the dearth of readily available information on most Alaskan species and their associated habitats. To date, much of our existing information focuses on game species and economically important fish species. We have focused little scientific attention on the nongame wildlife resources of the state, including invertebrates, amphibians, fish, birds, and the smaller mammals.

Information sources on these nongame species do exist, however: Alaskans engaged in subsistence activities possess a wealth of information about the life histories, preferred habitats, and changing conditions of the species they use. This knowledge, generally passed orally from generation to generation, is often referred to as traditional knowledge. Such sources exist, especially among Native elders and leaders, in communities across the state. Other sources of valuable information on CWCS species are commercial fishermen and long-established sport and commercial guides. For example, herring fishermen are acutely aware of seabird and marine mammal activity and often use these species to help locate targeted fish species and determine imminence of spawning. They also frequently have detailed timing and behavioral observations of species such as shorebirds and sea ducks that forage on herring eggs. Residents who hunt, trap, and fish often have valuable observations to share based on many years of activity in Alaska's wild lands and waters.

At expert meetings held during our planning process, we asked participants to provide ideas on how best to present relevant species distribution and abundance data. Many of them expressed concern about the lack of scientific data on a large number of the CWCS' potential target species and the high costs of gathering basic data on species distribution, abundance, trends, threats, and habitat parameters. Many also expressed concern about Alaska's lack of data management infrastructure, including GIS capability (see following subsection).

A key recommendation coming from scientists and other CWCS planning participants is to tap the network of knowledge that resides with Native Alaskans and other long-term resource users. Another was to promote and facilitate meaningful participation by remote communities in monitoring and sharing information about the species they use. This knowledge and information can then be combined with Western scientific data to better conserve and manage Alaska's diverse resident and migratory species.

Lack of Spatial Data, Data Systems, and Compatible Terms

During development of the CWCS, ADF&G identified a number of management tools that were either partly or entirely unavailable for our efforts. It will take a high level of commitment by all state and federal agencies, as well as other conservation-oriented organizations, to make progress in this arena to the benefit of our future management efforts.

In this first Alaska CWCS, we did not attempt to work with area-or species-specific spatial data. Species information from the AKNHP "Biotics 4" database was incorporated whenever practical. (Biotics 4 is the newest generation of NatureServe's biological data management software.) Also, ADF&G provided SWG program funding to the AKNHP to summarize recent information on species, and to provide current state status ranks for them. Status ranks reflect the species' vulnerability and range, from S5 "Secure" to S1 "Critically Imperiled."

ADF&G also was unable to incorporate certain themes in as much depth as we would have liked, but these will be incorporated into future iterations of the Strategy. These themes are species migration patterns, a systematic analysis of data gaps in species' distribution information, cultural and subsistence information, and traditional knowledge of our indigenous peoples. Future iterations of the Strategy should also compile information on collaborative efforts with other states (Washington, Oregon, California) and countries (Canada, Mexico, Russia, Japan) that manage habitats used by wide-ranging and migratory Alaskan species.

Spatial Data
Sound management and conservation of species requires spatial data. However, the development of detailed land cover data layers is in its infancy in Alaska, and challenged by the size of the state; this problem is even more overwhelming when applied to the marine environment. Even when data exist, different thematic classifications and resolutions hamper integration across regions. In addition, a consistent boundary between terrestrial systems and coastal waters is often lacking. Most existing systems lack accuracy assessments. Spatial data are generally lacking for distribution of nongame animals, including those living in benthic, subtidal, and intertidal ecosystems. Participants in our planning process found that available data was often at a coarse scale, incomplete, or in need of expert review and updating. Preferred habitats of nongame species generally are also unknown, so habitat models cannot be developed. Because the state and its component ecoregions are so large, it is more practical to use coarse-scale information because it tends to be more comprehensive. Assessment at this scale provides needed ecological context for the species we want to manage, but its utility for finer-scale land management decisions is limited. Typically, some areas in an ecoregion have been studied more intensively than others, creating disparities in the quality, type, and scale of data available.

Land status data also exists at a very coarse scale. For other than municipal lands, spatial data at the section level tends to miss most private lands, including lands owned by Native corporations, individuals, and local governments. Even if this level of information were available, there is no consistent framework for applying conservation status categories, such as those used by the USFWS GAP program or IUCN, to Alaska's unique land laws and diverse management prescriptions for federal, state, and private lands. Spatial data regarding land use is incomplete. In some ecoregions, comprehensive road coverage is unavailable requiring data sets to be stitched together even though scales and resolutions vary widely. Much of the infrastructure data related to the oil industry is considered proprietary, and thus unavailable. Data sets for locations of ports, shipping routes, primary trails, ice roads, and tundra scars are inadequately mapped or not readily available. No one agency holds data for active oil and gas leases, so data sets must be compiled from private, state, and federal entities. Human impact information could be improved by translating printed information, like that compiled in the recent report "Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope," published by the National Academies Press, into a spatial format.

Spatial analysis, under the broader discipline of "landscape ecology," has tremendous power for understanding how patterns in the physical, biological, and cultural landscapes influence and interact with ecological processes. Landscape ecology includes spatially explicit modeling of habitat quality based on species occurrence or biological fitness and the subsequent prediction of how proposed human developments, which often fragment natural habitats, may influence species

distribution or abundance in other areas. Expansion of this capacity is particularly important for conservation, because decisions on resource development often must be evaluated based on limited or nonexistent data, but in a timely manner.
In recent years, greater emphasis has been placed on documenting the observations and knowledge of Alaska Natives and rural residents. Yet effort is still needed to archive and manage this information for both ongoing and new projects. Standardized data management protocols are needed to ensure that projects are complementary and that research results are preserved. In addition, the information should be managed in ways that make it available to rural communities and the people who contributed it. Currently, the proposed Arctic Peoples' Observation Center (APOC) provides one example of a central data portal providing data management service and networking service related to the knowledge of Arctic peoples. APOC is designed to serve indigenous knowledge projects and Arctic communities by developing new management systems for data in nonnumerical formats, such as video, audio, maps, artwork, photographs, and context-specific data, such as interviews and recorded oral histories. Linkages with this effort might create a synergistic effect for the CWCS and conservation activities of many partners.

Birds

Of all taxa covered in the Strategy, the greatest amount of data exists for birds. Among the different groups of birds, data are most available for migratory landbirds, raptors, shorebirds, and waterbirds. Densities for nesting and breeding are known for many species through existing surveys such as the USFWS Aerial Breeding Pair Surveys, annual Breeding Landbird Surveys, and ongoing raptor monitoring efforts of USFWS, NPS, BLM, and ADF&G. Other sources, such as the USFWS Seabird Colony Catalog, are in need of updating. The Seabird Colony Catalog is only useful for those species that are colonial nesters and does not include very reliable information on species with dispersed breeding populations.

In general, we lack information about the locations and use of habitats by many bird species outside their breeding and nesting season. Migratory stopovers and routes have not been mapped, or data are not easily accessible, although coastal migration sites and routes of shorebirds have been identified. The distribution of some birds remains unknown, except for anecdotal information and studies in small areas. Studies resolving genetic issues, particularly of island endemics, are typically lacking. The water quantity and quality needs of all birds, especially those that directly depend on waterbodies for nesting, feeding and other activities, are not well understood.

Most breeding landbirds in Alaska are not adequately sampled by any of the continental monitoring programs currently used throughout the rest of North America. Basic information on the distribution of species, their habitat associations, population sizes, and trends is lacking. Several well-established and widely accepted methodologies used throughout the conterminous United States and southern Canada provide insufficient coverage and potentially biased information in Alaska. For example, the USFWS and Canadian Wildlife Service North American Breeding Bird Survey routes are restricted to the existing road system, which covers only a tiny fraction of Alaska's area and available habitats. The Audubon Society Christmas Bird Counts are largely clustered in the small fraction of urban areas in the state and miss a large percentage of potential winter habitats. The Monitoring Avian Productivity and Survivorship (MAPS) program, developed by the Institute for Bird Populations, has been useful in documenting changes in population, productivity, and survival for large numbers of birds in most of North America, but is only able to detect a statistically significant change in these parameters for a handful of species in Alaska. In an effort to address traditional program limitations, Boreal Partners in Flight and USGS developed the Alaska Landbird Monitoring Survey (ALMS) to monitor long-term trends in breeding landbirds in all ecoregions of Alaska. ALMS is a statistically rigorous, standardized methodology based on a stratified random sampling design. Despite a 2004 Memorandum of Understanding among ADF&G, USFS, USFWS, USGS, BLM, NPS, AKNHP, Alaska Bird Observatory, and Audubon agreeing to support and execute the ALMS, greater participation and sampling will be required in order to detect significant population changes for most landbirds in Alaska.

Terrestrial Mammals

Northern flying squirrel J. Nichols, ADF&G

The distribution of many small terrestrial mammals remains unknown except for anecdotal information and isolated studies in small areas. Specific habitat use and migratory movements of most mammals have not been mapped. It may be more appropriate to model these habitat uses and migratory routes once adequate land cover data are available. There is a need for additional understanding of the genetic relationship among island endemics and their taxonomic status.

Marine Mammals

Areas of open water, including leads and polynyas, are important habitats for marine mammals, but they have not been reliably mapped. Haulout locations have been mapped for many marine mammals, but recent data about their use is lacking, and habitat use information for other portions of a species' life cycle is typically unavailable. Movement patterns and haulout locations of some marine mammals are difficult to map due to their relationship to ice. The Alaska Habitat Management Guides (circa 1985) are available for some species (e.g., ringed seals), but were not incorporated into the CWCS because they are now outdated. The Guides need to be updated and thoroughly reviewed by biologists to reflect current knowledge. Because of the changing habitat conditions for many marine mammals (e.g., timing and extent of sea ice), defining and mapping consistent concentration areas will remain a challenge. The influence and effects of freshwater input on the estuarine environment and forage species of marine mammals is not well known in Alaska.

Fish and Aquatic Invertebrates

Information on life history, species distribution, and habitat associations of nongame freshwater fish is virtually nonexistent in Alaska. Some information about habitat use and distribution can be gleaned from the ADF&G Fish Distribution Database, which includes the Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes and its associated atlas. However, less than 50% of the streams, rivers and lakes actually used by anadromous species have been documented across the state. Another problem is that the database does not provide specific habitat data for river segments or data regarding nonanadromous resident fish species distribution. Freshwater data, such as stream habitat information, is sparse and disjunct. As a result, smaller lakes and lakes directly or seasonally connected by rivers are not always represented on larger scale maps, such as 1:1,000,000. Hydrologic Unit Classification (HUC) data currently available from the USGS may help refine this spatial data.

Known locations of many aquatic invertebrate and vertebrate species primarily result from opportunistic inventories and not from comprehensive surveys. The locations of overwintering areas used by invertebrates and resident fish, including springs, deep lakes or side channels of rivers, are not generally known for most watersheds in the state. Data on spawning and rearing areas and refugia sites are also poorly known. Since the early 1980s when the Alaska Habitat Management Guides were written, there has been no central repository for the fish habitat data of agencies and nongovernmental organizations.

The mayfly *Rhithrogena*
D. Gregovich, ADF&G

Amphibians
Specific habitat use, including water quantity needs, and dispersal pathways, of most amphibians have not been mapped. It may be more appropriate to model these once adequate land cover data are available. The distribution of many amphibians remains unknown except for anecdotal information and isolated studies in small areas. Conclusive studies resolving genetic issues, particularly of island endemics, are typically lacking.

Terrestrial Invertebrates
Similar to other taxonomic groups, there is an absence of general and site specific knowledge about species. The habitat use and distribution of most species remains unknown except for anecdotal information and studies in small areas.

Ecological Systems
In the absence of information about species and habitats, ecological systems can act as surrogates. To facilitate this in Alaska, resources need to be devoted to developing terrestrial, freshwater, marine, and coastal ecological system classifications and maps for the various ecoregions. The classification of ecological systems as an alternative to the long-term process of filling information gaps for every species should help the state improve decision-making and move more quickly with on-the-ground actions.

Management decision making might also benefit by increasing scientific data on relevant geographic, climatic, and hydrologic factors.

Better resolution and/or coverage of digital elevation models (DEMs), geology, hydrology, hydrography, and glacier data sets would improve the compatible fish, wildlife and habitat resource selection models. When completed, the USGS National Hydrography Dataset (NHD) will provide detailed hydrologic information on water bodies throughout Alaska for evaluating aquatic ecosystems and the many species that depend on them. The state has recently begun using the NHD over the previously used DNR hydro data set for GIS applications. Biological inventories, aquatic resource assessments, ecological change detection programs, regulatory environmental impact and compliance evaluations, and accurate and precise hydrological monitoring and modeling all require digital, georeferenced mapping.

An ongoing need is to prioritize "at-risk" waterbodies across the state and, based on those results, provide adequate instream flow/water volume protection (quantity and quality) based on their importance for fish and wildlife. Such efforts are critical to sustaining ecosystem functions important for both aquatic species and terrestrial species that depend on water resources for survival.

Recommendations to Collaboratively Address Gaps and Needs
The efforts of ADF&G benefited significantly from the input of numerous other governmental agencies, nongovernmental organizations, academia, residents, Native organizations, and consultants. Continued collaboration among stakeholders and future involvement of landowners and industry will help identify and address important data gaps and provide useful information for land use and management decisions affecting Alaska species.

Following are some suggestions for addressing data issues across multiple cooperators and taxonomic groups:

a) Reconvene CWCS stakeholders and invite additional experts to review preliminary results and prioritize data gaps; develop shared research and inventory agendas among stakeholders.
b) Support USGS GAP in developing digitized species range maps showing gaps and uncertainties, land cover maps showing vegetation classifications, and stewardship maps that show conservation status and level of management; similar information is needed for coastal, marine, and freshwater systems.
c) Explore other tools for increasing data capacity through the use of model-based predictions of species distribution and abundance, GIS platforms, such as the Global Biodiversity Information Facility (www.gbif.org), and related approaches.
d) Increase capacity of ADF&G in spatial database management and information sharing for all species under its jurisdiction in cooperation with the Alaska State Geo-Spatial Data Clearinghouse (http://www.asgdc.state.ak.us/)
e) Encourage ADF&G and partners to share spatial data and its associated metadata on the Internet, possibly through University of Alaska Fairbanks, which now coordinates a Geospatial Metadata Server (GMS: http://www.geo.ed.ac.uk/~anp/gms/main.htm). Develop and maintain

department website for this purpose, perhaps similar to the NPS Alaska Region Inventory and Monitoring Program (http://www.nature.nps.gov/im/units/AKRO/index.htm).

f) Update the species and information in the Alaska Habitat Management Guides (1985), e.g., by first digitizing the range maps to provide baseline spatial data on species distribution that could be easily updated with current knowledge.

g) Translate written, tabular, and other database information into a spatial context; as part of this, direct effort toward gathering traditional and local user knowledge and integrating it, along with Western scientific knowledge, into accessible databases that include spatial components whenever possible and appropriate.

h) Explore options for developing data in nonnumerical formats, linking with existing projects as appropriate, to enhance communication with rural communities and Alaska Natives.

i) Assess importance of Alaska to/for individual species (i.e., what percent of each species' range occurs in Alaska); identify key ecological attributes of species and habitats and select monitoring targets at differing scales (circumpolar, ecoregion, landscape, habitat) and for different purposes (e.g., detection of invasive species introductions, modeling of habitat effects due to climate change).

j) Collaborate with existing international monitoring and biodiversity protection efforts, e.g., the circumpolar biological diversity working groups operating under the auspices of the Arctic Council (see Section VIII).

k) Develop uniform/integrated marine (including benthic and nearshore), coastal, and freshwater classification systems.

l) Complete detailed assessments and descriptions for each of the state's ecoregions.

m) Complete regional habitat assessments (system types), and evaluate habitats that are important or limiting for a species (i.e. boreal forest, Arctic tundra); identify the percentage of important habitat types already in conservation status.

n) Develop statewide habitat maps, which include the means to track and report on cumulative changes resulting from climate change, habitat alterations, contaminants, etc. The maps also could help determine regional conservation priorities.

o) Conduct connectivity analyses with emphasis on dispersal and migration routes (e.g., for birds, whales, mammals, amphibians, anadromous fish); identify and compile information on routes and timing of use, and provide to decision-makers.

p) Develop an operational plan for increasing our knowledge about distribution, abundance, habitat requirements, and life history of nongame species.

q) Develop MOUs and partnerships covering such areas as:
   - Protocols for data sharing (e.g., national and international LTER programs);
   - Monitoring networks;
   - Partnering networks (models include those used under the Exxon Valdez Oil Spill [EVOS] Gulf Ecosystem Monitoring [GEM] program, Alaska

Ocean Observing System [AOOS], and North Pacific Research Board [NPRB]);
    - Management of Traditional Ecological Knowledge;
    - Regional partnerships like the North Slope Science Initiative (NSSI).

r) Assess the types of information decision-makers in Alaska currently have available; identify needs and products that would improve the decision-making process.

s) Work with other partners to support a single, statewide database that includes a spatial component and makes species information available to managers, planners, and developers.

t) Continue participation in the existing statewide species working groups, such as Boreal Partners in Flight, to coordinate conservation efforts; explore needs and options for formation of new groups.

u) Continue to add species information to the AKNHP Biological Conservation Database (BCD) and update species status ranking information (i.e., how imperiled are some of Alaska's species according to national/global ranking protocols).

Insufficient Public Understanding About Fish and Wildlife Needs

Enhancing Alaska's data collection, management, and presentation infrastructure are critical elements in providing long-term conservation of its species and habitats. In reality, many years will probably elapse before this state acquires the level of coverage and capability, including training in cutting-edge analytical tools, that land use and wildlife managers employ in other states. In that time, Alaska's population and its influx of seasonal visitors are expected to increase, further complicating the task for Alaska's natural resource managers.

According to the Alaska Department of Community and Economic Development, nearly 1.3 million visitors arrived in Alaska in 2002, a 6 percent increase from the previous year. Also, Alaska saw a 55.4% increase in numbers of summer visitors from 1994 to 2004. If the same growth rate applies in the coming decade, by 2015 Alaska will be hosting nearly 2 million visitors each summer. Meanwhile, the numbers of state residents is expected to increase at a rate of 1.0 to 1.5% annually; a portion of this increase may be due to visitors and military personnel who decide to make Alaska their home.

As elsewhere in the nation, a growing percentage of the state's population will be senior citizens. For the past decade, the rate of growth of the over-65 population in Alaska was second only to that of Nevada (Goldsmith 2004). The state's urban areas will continue to see a large influx of Alaska Natives moving from rural places (Goldsmith 2004). Given that people 19 and younger make up 44% of the Native population (compared to 29% of all Americans), a large number of Native immigrants to Alaska's urban centers will likely be school-age (Goldsmith 2004).

Fostering informed decision-making and involvement in conservation and management issues is important to achieving the goals of the CWCS and avoiding degradation of fish- and wildlife-related opportunity. The public, elected officials, and other decision makers will take actions that influence conservation positively or negatively, based on the level of understanding they possess. However, there are many challenges to reaching these audiences with information and education that will enable them to assist in conservation efforts.

Reaching remote villages throughout Alaska requires use of various forms of media, partnerships with multiple tribal entities, and effective cross-cultural communication. As conservation needs for various species change, these outreach efforts are crucial to keeping large numbers of people who interact directly with fish and wildlife updated and engaged in actions addressing those needs.

Sampling invertebrates in the Chena River
ADF&G

The education and outreach (EO) efforts conducted by ADF&G, other agencies, and nongovernmental organizations constitute an essential tool for achieving better conservation of Alaska's diverse wildlife resources. EO programs result in:

- increased public knowledge about basic biological concepts, ecosystem relationships, and wildlife conservation principles and regulations;
- increased understanding of the natural and human processes occurring in Alaska's terrestrial, riparian, freshwater, coastal, estuarine, and marine environments;
- opportunities for citizens, including through "citizen science" initiatives, to help gather needed traditional knowledge or scientific data, and monitor trends in species, species assemblages, and habitats; and
- public support for, and participation in, scientifically based decision-making about species and the habitat elements needed to produce them.

Implementing a comprehensive statewide strategy offers opportunities for outreach to, and involvement of, many constituencies. For example, encouraging retirees as well as young people to become involved in "citizen science" efforts may prove to be a win-win proposition. Further, all citizens will benefit from readily available and user-friendly public information.