U.S. Fish & Wildlife Service

Wildlife Response to Environmental Arctic Change

Predicting Future Habitats of Arctic Alaska

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Ice floating in a lagoon near Collinson Point in the Arctic National Wildlife Refuge. Photo by Philip Martin.

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Report from the
Wildlife Response to Environmental Arctic Change (WildREACH):
Predicting Future Habitats of Arctic Alaska Workshop
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Table of Contents

Chapter 1
Executive Summary

Climate is changing worldwide, but the Arctic is warming at a rate almost twice the global average. Changes already observed in arctic terrestrial landscapes include rapidly eroding shorelines, melting ground ice, and increased shrub growth at high latitudes. Because the Arctic will likely experience early and disproportionately large impacts of climate change, the U.S. Fish and Wildlife Service (Service) has identified America's Arctic as a priority region for developing management strategies to conserve fish, wildlife, and their habitats.

The Service convened a Wildlife Response to Environmental Arctic Change (WildREACH) workshop on 17–18 November 2008 in Fairbanks, Alaska. Our goal was to identify the priority research, modeling, and synthesis activities necessary to advance our understanding of the effects of climate change on birds, fish, and mammals of arctic Alaska, focusing on terrestrial and freshwater systems. We used a conceptual modeling approach to identify the potential changes that would most strongly influence habitat suitability for a broad suite of arctic species. In doing so, we embarked on the first essential step toward incorporating climate considerations into biological planning and conservation design for the Arctic. The workshop was attended by over 100 participants representing federal and state agencies, academia, and commercial and non-profit organizations. WildREACH provided a forum for communication among specialists from multiple disciplines, a vital first step toward establishing effective partnerships. Summaries of each workshop report chapter are provided below.

Climate, Permafrost, Hydrology

The average annual temperature of Alaska's North Slope is projected to rise approximately 7°C by 2100. The magnitude of change is imprecisely known, but Global Circulation Models identify northern Alaska as one of the fastest warming regions of the planet. Annual precipitation is also expected to increase, although there is less certainty surrounding this prediction.

In the Arctic, climate affects habitat uniquely through the interdependencies of permafrost, hydrology, and vegetation. The deep, cold, continuous permafrost of the North Slope represents a reservoir of resilience for this landscape. Nevertheless, enhanced seasonal melting of near-surface ice is already measurably altering habitats and hydrology. Understanding how variation in the type and quantity of ground ice influences a landscape's susceptibility to warming is fundamental to predicting the extent and magnitude of habitat change.

Hydrologic processes are a pivotal determinant of climate-influenced habitat change in arctic Alaska. Changes in overall water balance and in timing and magnitude of seasonal water and energy fluxes will strongly affect habitat availability and quality for arctic-adapted species of fish and wildlife. The seasonal allocation of precipitation is key to ecosystem response in an environment where water remains frozen most of the year. Despite the expectation of higher annual precipitation, models predict a generally drier summer environment. Refining models to more confidently predict water balance and the resultant water supply available to various habitat types is one of our most important challenges.

The presence of ice-rich permafrost soils makes arctic tundra uniquely vulnerable to the effects of warming. Photo from USFWS, Ikilyariak Creek, Arctic National Wildlife Refuge.

Habitat Change

Effects of climate change on North Slope habitats will vary depending on the permafrost-influenced geomorphic processes specific to particular ecosystems. It is useful to consider the coastline, Coastal Plain, Foothills, and floodplains separately.

- In the coastal zone, rapid shoreline erosion is occurring, associated with the retreat of summer sea ice. Rising ocean temperatures, sea level rise, permafrost degradation, increased storm surges, and changes to river discharge and sediment transport will continue to affect habitat availability and quality in the coastal zone.

- The vast shallow wetlands of the Coastal Plain landscape are sensitive to changes in water balance that could lead to drying. Lakes may enlarge through melting and erosion at their edges. Alternatively, lakes may drain if surrounding ice wedges degrade, resulting in the formation of new drainage networks.

- The hilly terrain of the Arctic Foothills is prone to thaw slumps and gully formation. In the lower Foothills, extremely ice-rich soils are susceptible to ice wedge degradation, melting of massive ice, and formation or drainage of thermokarst lakes.

- Floodplains are very dynamic landscapes and could respond to climate change in a variety of ways. Floodplain processes are influenced more strongly by extreme flood events than by average conditions, and models of future flood frequency and severity must be better developed in order to predict habitat change.

Historically, tundra fires have been rare on the North Slope, but fire frequency will likely increase as the climate warms. A positive feedback relationship exists whereby soils tend toward a warmer and drier condition after fire, which in turn promotes shrub growth and a more fire-prone landscape. Although widespread conversion of North Slope tundra to spruce forest is not expected within this century, increased shrub cover has been documented in the Brooks Range and Foothills, a trend that is expected to continue. Changes in plant phenology (e.g., earlier green-up and senescence) are certain to occur as spring melt comes earlier.

Climate change may increase availability and uptake of contaminants for fish, wildlife, and their habitats. Contaminants currently contained within glacial ice, multi-year sea ice, and permafrost, including persistent organic pollutants and mercury, will almost certainly be released to aquatic ecosystems as the temperature rises.

Spring melt is accompanied by a sharp peak in flow for rivers that arise in the Brooks Range—changes in precipitation and warming temperatures may change flow regimes and sediment transport in arctic rivers. Photo from USFWS, Sadlerochit Mountains, Arctic National Wildlife Refuge.

Climate Effects on Fish and Wildlife

WildREACH workshop participants formed working groups for birds, fish, and mammals. Each working group developed conceptual models to illustrate hypotheses of likely pathways by which fish and wildlife populations of arctic Alaska may be affected by climate change. Hydrologic process models for summer and winter provided linkages among climate variables, physical processes (hydrologic and permafrost), and habitat change. These processes were relevant to all species groups.

The bird working group developed conceptual models organized around four broad topics: abundance and distribution of surface water, vegetation community change, invertebrate community change, and coastal processes.

The fish working group developed a single conceptual model emphasizing pathways related to the effects of increased water temperature and hydrologic changes related to soil moisture, glacial input, drainage changes related to permafrost degradation, and changes in lake area.

The mammal working group developed separate models for the summer and winter seasons. Key factors in winter included changes in the timing, amount, and nature of precipitation (e.g., rain-on-snow events, deeper snow). In summer, changes in plant species composition, amount of forage, and seasonality were expected to have the greatest potential for affecting mammal populations.

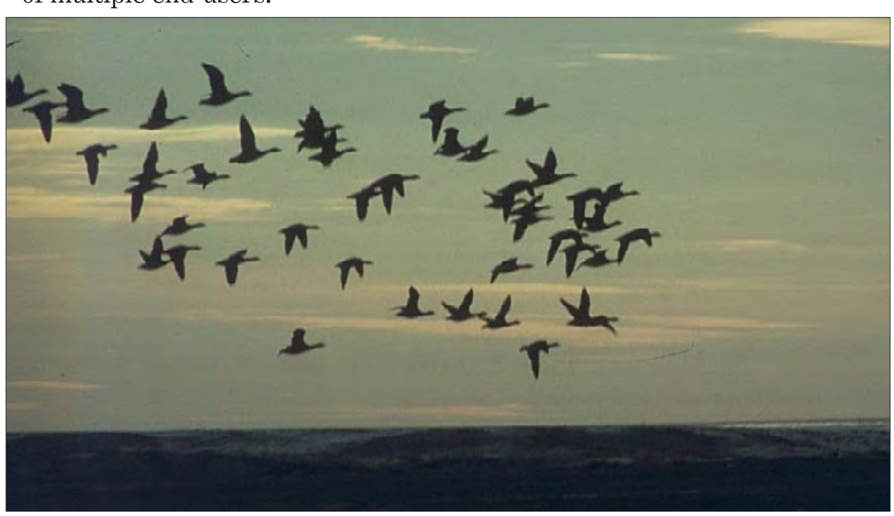
Common Themes and Research Gaps
Despite the uncertainty in projecting climate change impacts on arctic species and habitats, workshop participants identified monitoring, research, and modeling priorities that will help improve our understanding of future conditions. Specific information gaps varied among species groups, but most fell into four cross-cutting themes: 1) changes in precipitation and hydrology; 2) changes in vegetation communities and phenology; 3) changes in abundance and timing of invertebrate emergence; and 4) coastal dynamics.

All working groups emphasized that predictions regarding climate effects on fish and wildlife populations must be tentative, given the uncertainty surrounding climate forecasts and unavailability of models that couple climate, geophysical, and ecological processes at appropriate spatial and temporal scales. All working groups agreed that in order to more accurately predict climate change effects on species and habitats, multidisciplinary work is needed to better understand the underlying biological and physical processes that drive terrestrial and aquatic ecosystem function and the response of those systems to climate change. Hydrologic processes, in particular, are pivotal determinants of climate-related habitat change, and enhanced data collection and modeling in this area will benefit multiple users.

All working groups emphasized that information available on life history, habitat requirements, distribution, abundance, and demography is inadequate for many arctic species. Basic biological studies, therefore, are also needed. Focal species should be chosen based on their predicted vulnerability to climate change and potential to serve as indicators of hypothesized habitat changes.

Conclusions and Recommendations
WildREACH workshop discussions revealed several specific information gaps within the four major thematic areas previously listed (see Table on page 7). These gaps represent the highest scientific priorities for scientific inquiry, which should be pursued in an organized, multidisciplinary fashion. Specific recommendations include:

1. Establishment of at least three long-term observatories on the North Slope to collect integrated hydrologic, climate, and geophysical data. The central mission of these observatories should be to develop an understanding of the response of permafrost (active layer dynamics), hydrologic, and ecological systems to changes in thermal regime. To ensure applicability to fish and wildlife biology, water budgets should be estimated for key ecotypes.
2. Intensive observations at the observatory sites should be supplemented by instrumentation (e.g., meteorology, radiation, stream discharge, soil moisture) at dispersed sites arrayed across important environmental gradients.
3. Modeling that dynamically couples soil thermal and hydrologic regimes, and biological systems at appropriate spatial and temporal scales.
4. Centralized data storage and interpretation for the mutual benefit of multiple end-users.



A flock of black brant migrate along the Beaufort Sea coast. Optimal timing for bird migration could change under an altered climate regime. Photo by Philip Martin from Canning River delta, Arctic National Wildlife Refuge.

We also recommend immediate attention to developing predictive models of habitat change, focusing initially on processes that are occurring now and that act on short (e.g., decadal) time scales. Priority topics include:

1. Coastal processes (e.g., erosion, storm surge, deposition, vegetation succession);
2. Seasonality (e.g., plant phenology, animal migration, life stages of aquatic invertebrates);
3. Shrub advance;
4. Fire regime (as a function of interactions among climate, permafrost, and vegetation); and
5. Thermokarst effects on surface water storage, drainage systems, and lakes.

The Service should engage the U.S. Geological Survey (USGS) and others in a structured decision-making process to refine the selection of indicator species/parameters as components of a long-term climate monitoring program. Upon reaching consensus, management agencies should seek stable funding for monitoring these species/attributes.

The Service recognizes that we must change the way we do business to succeed in managing fish, wildlife, and their habitats in a rapidly changing climate. We can no longer manage for the *status quo*—we must manage for an uncertain future. These challenges exceed the capacity of any one agency, and we must pool our collective resources. By strategically targeting financial resources, we can build Landscape Conservation Cooperatives that increase capacity, eliminate redundancy, and provide the technical expertise to implement conservation, research, and management at all scales.

The Service will improve communication and collaboration with the arctic research community to initiate building of wide-ranging partnerships. On a local, regional, and national level the Service will:

1. Work with the National Science Foundation (NSF) to define climate research priorities relevant to resource management agencies;
2. Increase collaboration with academia and other researchers to develop grant proposals that address priority questions;
3. Participate in planning and implementation of the interagency Study of Environmental Arctic Change (SEARCH) Program to ensure inclusion of research relevant to resource management agencies;
4. Work with arctic science program managers in the research agencies (e.g., NSF, USGS, National Oceanic and Atmospheric Administration) to obtain funding for work that addresses priority questions; and
5. Promote a collaborative approach to acquire, process, archive, and disseminate essential satellite-based remote sensing data products (e.g., snow cover, green-up, and surface water) needed for regional-scale monitoring.

Climate change presents an unprecedented challenge to managers of arctic natural resources. By initiating a collaborative process among biologists, physical scientists, and managers, the WildREACH workshop successfully identified priority information gaps and activities needed to provide the basis for adaptive management of arctic fish and wildlife resources. Since the workshop, the Service has identified America's Arctic as Alaska's first Landscape Conservation Region, which will be supported by the technical capacity housed in the Northern Alaska Landscape Conservation Cooperative. Adopting the WildREACH recommendations is the next step in strengthening our capacity to anticipate climate-related habitat change and to identify the most promising strategies to conserve fish and wildlife populations in America's Arctic.

An undercut bluff on the Beaufort Sea coast, the result of a severe storm in August 1980, illustrates the susceptibility of ice-rich coast to rapid erosion. Photo by Catherine Moitoret, Canning River delta, Arctic National Wildlife Refuge.

Scientific Priorities

Workshop participants identified important information gaps in our understanding of climate change effects on birds, mammals, and fish populations. The specific gaps varied among species groups, but most fell into four cross-cutting thematic areas and underlying research questions (see Chapter 6 for more details):

1. Precipitation, Water Balance, and Distribution of Surface Water

a. How reliable are the projections for increasing precipitation and evapotranspiration?
b. How will the annual precipitation input on the Coastal Plain and Foothills be allocated between winter (snow pack) and summer?
c. How will changes in precipitation, evapotranspiration, and active layer depth alter summer surface water availability in shallow-water and mesic/wet tundra habitats?
d. How will changing patterns of seasonal runoff affect stream flow?
e. What is the contribution of groundwater in various systems, and is it sufficient to maintain year-round flow?
f. Will drought conditions and changes in drainage patterns decrease water body connectivity?
g. Which Coastal Plain lakes are susceptible to tapping (rapid drainage) and on what time scale?
h. What are the expected changes in snowpack characteristics (depth, density, presence of ice layers) and how might these vary on a regional and local scale?
i. How much change will occur in the timing of snow melt and snow onset?
j. How will the frequency of rain-on-snow and severe winter storm events change?

2. Vegetation Community Composition and Phenology

a. How will changes in the length and timing of the growing season influence plant phenology, including seasonal changes in nutritional quality?
b. How will plant species composition shift in response to long-term climate change, and what are the implications for habitat structure and quality of the prevalent available forage (i.e., digestibility, nutrient content)?
c. What is the time scale of expected shrub increase, and how will this vary by species/growth form (low vs. tall shrub) and ecoregion?
d. What is the likelihood of widespread conversion from sedge and sedge-shrub meadow to bog meadow (paludification) and how would this affect herbivore and detritus-based trophic systems?
e. How will changes in the seasonality of stream discharge and occurrence of flood events influence development of riparian vegetation communities?

3. Abundance and Phenology of Invertebrates

a. How does earlier spring thaw affect timing of life cycle events and peak availability to predators?
b. How does temperature affect growth and development of aquatic insects?
c. What climate-related changes are likely in community composition of macroinvertebrates in stream, lake, and saturated soil environments?
d. How will changes in the distribution and quality of surface waters and shifts from pelagic to benthic productivity in deep lakes affect availability of macroinvertebrates to fish and wildlife?
e. How will warming and changing seasonality affect abundance and peak activity periods of biting insects and what are the bioenergetic consequences for caribou in particular?
f. How will warming and changing seasonality affect the prevalence of parasites and disease vectors (e.g., nematode parasites of muskoxen and Dall's sheep)?

4. Coastal Dynamics

a. Will higher water temperatures, sea level rise, and retreat of summer sea ice cause degradation of the barrier island systems of the Beaufort and Chukchi seas?
b. Will alluvial deltas continue to build or will rising sea levels outpace potential increases in sedimentation rates?
c. How quickly will shoreline retreat result in newly breached lake basins?
d. To what extent will coastal erosion, in combination with sea level rise, cause salinization of low-lying coastal areas?
e. Will coastal wet sedge meadows establish at a rate equal to loss of this habitat through erosion and inundation?
f. Will increased fogginess/cloudiness exert a negative or positive feedback effect on air temperature in the coastal zone? What is the expected spatial extent of this effect?