Executive Summary and Report on the
U.S. Fish & Wildlife Service
&
U.S. Geological Survey

Climate Change Forum for Alaska

February 21-23, 2007
Anchorage, Alaska

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EXECUTIVE SUMMARY

This report summarizes the proceedings of the February, 2007 Climate Change Forum for Alaska coordinated by the U.S. Fish & Wildlife Service (FWS) and U.S. Geological Survey (USGS). It is intended to be used as a tool for identifying next steps in addressing the pressing threats of climate change in the region.

Scientific evidence confirms that the earth is undergoing a change in climate. The Intergovernmental Panel on Climate Change (IPCC), an international consortium of researchers and scientists, asserted that "warming of the climate system is unequivocal," in its recently released first chapter of its Fourth Assessment Report.[1] Numerous other reports support this finding, and many underscore that the impacts of climate change are expected to be particularly dramatic in high-latitude areas such as Alaska and the Arctic.[2,3,4] Global impacts already documented include higher average annual temperatures, changes in precipitation and run-off, rising rivers, species shifts, and thawing permafrost. Predictions include even more dramatic changes in the future.

Climatic changes and the effects on Alaskan flora and fauna challenge the Fish & Wildlife Service's mission to conserve trust species. The Future Challenges Workshops in August 2004 and June 2005 identified climate change as a priority at national and regional levels, while this Climate Change Forum for Alaska addressed the topic at an ecoregional scale within Region 7. The Forum was jointly planned by the FWS and USGS and held in Anchorage on February 21-23, 2007. Prior to the Forum, a steering committee met weekly for nearly a year to plan the agenda, identify topics for discussion, organize logistics, and secure presenters. Topics for both the technical presentations and breakout sessions were selected from responses to a questionnaire sent to Alaska Region employees to determine their greatest concerns about climate change, information needs, and the most pressing issues facing them with respect to climate change. Throughout the planning process, the steering committee briefed the Regional Director on the Forum's progress, and held briefings with the Regional Directorate. The committee maintained contact with partners to discuss plans, network, and receive feedback. An information clearinghouse was set up on the FWS website, with links to recommended reading, the forum agenda, and statewide maps.

During the 3-day Forum, FWS and USGS employees attended a 1-day conference where current scientific findings were presented, and then spent 2 days participating in internal meetings to brainstorm opportunities for addressing climate change in the region. Because Alaska is predicted to be significantly affected by climate change, the FWS and USGS must begin planning proactive strategies in anticipation of those changes, rather than adopting reactive approaches of lesser effectiveness.

The **goals** for the Forum were to:

1. Inform resource professionals about natural resources in Alaska that may be affected by climate change;
2. Strengthen communication and collaboration among FWS and USGS scientists and project leaders in Alaska;
3. Initiate a process to address the effects of climate change in Alaska in light of agency missions and statutory mandates;
4. Provide the opportunity for FWS cross-programmatic collaboration to address climate change concerns.

During the first day of internal meetings at the Forum, participants focused on the effects of climate change using statewide Ecological Planning Units (EPU) as a framework. During EPU group discussions, effects of climate change on wetlands and vegetation communities were most frequently cited as priority concerns. The following day, participants broke into different groups, addressing climate change effects through broad themes such as species of conservation concern, planning, and inventory and monitoring.

Several **clear recommendations** emerged from the conference, including both short-term, immediate actions, and long-term proposals. While participants made a consistent call for more research and analysis of the specific effects of climate change, there was general consensus that some scientific questions may never be answered.

Managers can make decisions using existing information to the best of their ability, while also incorporating and adapting to new information as it becomes available. Participants recommended immediate efforts to anticipate the effects of climate change, and to integrate predicted changes into resource planning.

Forum recommendations are grouped into **immediate actions** and **long-term planning**. Long-term, comprehensive recommendations fell into three categories: **partnerships, science,** and **internal agency policies**.

Immediate Actions

- The FWS and USGS should each hire a **Regional Climate Change Coordinator in Alaska** to facilitate communication and research projects within the agencies, and between the agencies and partners. Specifically, the FWS position would:
    - Coordinate closely with partners in the USGS and other agencies;
    - Facilitate and encourage climate change communication among employees and within divisions;
    - Promote integration, coordination, and data exchange on climate change between Service programs;
    - Coordinate EPU working groups, initially establishing a prototype group.
- The combined FWS/USGS Regional Directorate should **continue the round table discussion**, initiated at the Climate Change Forum, with other federal and state agency leaders.
- Develop a **FY 2009 budget proposal** for climate change focused work. The proposal would include funding for inventory and monitoring, compilation of the state of knowledge, coordination with partners, and other priorities as they arise. Ideally this budget would be closely coordinated between the FWS and USGS.
- **Designate an EPU prototype** to continue work begun at the Forum. Many participants felt the EPU format worked well and recommended using it as a platform for continuing discussion, research, and action on climate change. As the Arctic is experiencing some of the greatest impacts from climate change, it is strongly recommended as the prototype.
- **Revise the FWS website** to incorporate climate change research. The site would include presentations from the Forum and links to ongoing efforts outside of the FWS, and could serve as a central information clearinghouse for regional employees. An example of the type of information is in **Appendix 1.**
- **FWS Region 7** and **USGS** representatives should **present findings/recommendations** and further progress on climate change work in Alaska at the **July FWS/USGS Directorate meeting** in Alaska.
- FWS should **partner** with the USGS on the **Yukon River Basin** Climate Effects Assessment and Benchmark Monitoring Plan.

Long-term Strategies

Partnerships

- Continue joint research planning and **expand partnerships** between the USGS and the FWS in Alaska:
    - Establish coordination mechanisms that foster information delivery via meetings, seminars, joint trainings, and more focused workshops (for EPUs or thematic areas).
    - Improve communication among USGS and FWS about ongoing and future climate change work in Alaska (for example: USGS Yukon River Basin Climate Effects Assessment and Benchmark Monitoring Plan).
- The management response to climate change must be addressed on an ecosystem scale. Therefore, the FWS will need to **partner with other groups** (both governmental, academic, and NGOs) on:
    - Compiling existing information into integrated datasets;
    - Developing predictive models;
    - Establishing inventorying and monitoring strategies;
    - Public outreach;
    - Strategic land conservation to ensure habitat connectivity for populations (i.e., Yellowstone to Yukon Initiative).
- Identify and contribute to **current, ongoing climate change research projects** outside of FWS.

Suggested projects include the Global Observation Research Initiative in Alpine Environments (GLORIA).

Science

- **Examine existing internal data** in relation to climate change. There was a consistent call for understanding and integrating information that FWS already has.
- After compiling existing data, **identify data gaps** to inform future research.
- Establish **physical-parameter monitoring stations**, particularly for stream gauging, weather, and air quality. There are currently too few of these stations in Alaska to adequately monitor these parameters at regional scales, and to provide a basis for predictive modeling.
- Develop **predictive models** to identify vulnerability of ecosystems, refuges, and species to climate change and its associated risk.
- Use **paleoecology** studies to examine the potential range of possible future changes.

Management Strategies and Policies (FWS)

- Develop an Alaska Region **policy statement**, consistent with DOI policy, for conserving natural diversity in the context of climate change.
- Begin discussing and determining **FWS direction and policy** with respect to climate change. Types of questions the Service must address include:
  - How will the FWS **adapt** to climate change?
  - What is the **timeframe** for action?
  - Do **regulations**, such as the Marine Mammal Protection Act and Endangered Species Act, need to be revised or interpreted in a manner to provide more flexibility in managing species impacted by climate change?
  - How will the FWS **prioritize** ecosystems and species on which to focus conservation efforts? Can and will the FWS allow species that face severe threats from climate change **go extinct,** and how will this decision be affected by public and partner response?
- Incorporate knowledge of climate change-related impacts into **position descriptions**.
- Establish climate change as an **umbrella issue**, and incorporate into management strategies.
- Create a process or **decision model** that incorporates climate change issues for prioritizing and implementing management decisions.

While climate change is a serious threat to the species, ecosystems, and resources managed by the FWS, the agency has effectively responded to major challenges in the past and has the capability to do so again. The USGS has the expertise to provide scientific support that will assist FWS managers in anticipating change and developing appropriate adaptive management strategies for the Service's trust resources in Alaska. Through aggressive, immediate planning to address climate change, including the use of science, partnerships, and internal policy changes, the Service can create an effective plan for conserving the natural resources under its stewardship. The global scale and perhaps overwhelming nature of the problem should not deter action. Excellent resources and partners provide opportunities to begin effecting positive responses and implementing successful management.

FORUM REPORT

Introduction

Scientific evidence confirms that the earth is undergoing a change in climate. Global impacts already documented include higher average annual temperatures, changes in precipitation, rising rivers, species shifts, and thawing permafrost. Future predictions anticipate even more dramatic changes, especially in Alaska and other northern regions.

Climatic changes and the effects on Alaskan flora and fauna challenge the Fish & Wildlife Service's mission to conserve trust species. The Future Challenges Workshops in August 2004 and June 2005 identified climate change as a priority at national and regional levels, while this Climate Change Forum for Alaska addressed the topic at an ecoregional scale within Region 7. The Climate Change Forum for Alaska, jointly planned by the FWS and USGS was held in Anchorage on February 21-23, 2007. Over the 3-day Forum, FWS and USGS employees attended a 1-day conference where current scientific findings were presented, and then spent the remainder of the forum participating in internal meetings to brainstorm opportunities for addressing climate change in the region.

During the first day of internal meetings at the Forum, participants focused upon the effects of climate change using statewide Ecological Planning Units (EPU) as a framework. The following day, employees broke into different groups, addressing climate change effects through broader themes such as species of conservation concern, planning, and inventory and monitoring. This report summarizes the proceedings, and is intended to be used as a tool for identifying next steps in addressing the pressing threats of climate change in the region. It includes summaries and primary recommendations from EPU and thematic breakout discussions, as well as a section with feedback on the Forum. A brief summary of recommendations is included, and a complete list of recommendations can be found in the Executive Summary.

Recommendations

Several clear recommendations emerged from the conference, including both short-term, immediate actions, and long-term proposals. While participants made a consistent call for more research and analysis of the specific effects of climate change, there was general consensus that efforts to anticipate the effects of climate change and to integrate such changes into resource planning should be undertaken immediately. Participants recognized that some scientific questions may never be answered. Managers can, however, make decisions using existing information to the best of their ability, while continuing to incorporate and adapt to new information as it becomes available.

Forum recommendations were grouped into immediate actions and long-term planning. Long-term, comprehensive recommendations fell into three categories – partnerships, science, and internal agency policies. Recommended immediate actions included hiring a Regional Climate Change Coordinator for both the FWS and USGS; designating an EPU prototype to continue work begun at the Forum; developing a FY09 budget proposal to address climate change; and partnering with the Yukon River Basin Climate Effects Assessment and Benchmark Monitoring Plan. Every breakout group emphasized the need to partner on research and outreach efforts. Other common recommendations included developing better predictive models; examining existing internal data in relation to climate change; continuing to aggressively deal with invasive species; and beginning the process of determining FWS direction and policy with respect to climate change.

EPU BREAKOUT SUMMARIES

Framework for discussions

During the second day of the Forum, and the first day of internal meetings, FWS and USGS employees broke into six separate discussion groups in which they brainstormed the effects of climate change upon individual Ecological Planning Units (EPU) in Alaska. Each group was provided a broad list of potential climate change effects, from which they selected priority topics. Within these topics the groups identified priority research and monitoring needs, management directions, outreach and education options, and potential partnerships. A copy of the matrix used to categorize these topics, and sample results from the discussions, can be found in Appendix 2. Maps of the EPUs are posted on the FWS regional website. While groups provided many overlapping recommendations and ideas, discussions followed divergent paths. Because group discussions ranged from big picture philosophical questions to very specific management issues, the recommendations from each group vary in scope. Many participants expressed concern that the issues chosen for discussion did not necessarily represent the highest priorities; rather, they represented what was manageable given the limited time available during the workshop. All agreed that the Forum served as a valuable launching pad for further internal and external conversations and actions addressing climate change in Alaska.

Aleutian EPU

Discussion Summary

To begin their breakout discussion, the Aleutian EPU group felt it was important to identify ecological drivers and unique characteristics of their particular EPU. The Aleutian EPU is dominated by a marine climate, and is also distinguished by the relatively shallow nearshore Aleutian Shelf; rich estuarine systems; marine derived nutrient deposition on the terrestrial system; and that the National Wildlife Refuges are the primary land stewards. Additionally, the EPU is important for freshwater aquatic systems: four of the six largest lakes in Alaska are within the region, and it includes several major salmon rivers. The terrestrial system was heavily glaciated in past but has no permafrost and there is volcanic activity with low wildfire activity.

The Aleutian EPU group brainstormed and exchanged ideas prior to the Climate Change Forum via e-mail, which helped the team move beyond the matrix provided. Because many of the specific issues had been identified prior to the forum, the group's recommendations were of a broader nature. The group emphasized two major recommendations – using "planned adaptation," and developing creative, innovative partnerships. Planned adaptation would include integrating and prioritizing an upgrade of research and knowledge; tangible actions; legislation and regulation; and regional cooperation. The group noted that planned adaptation activities will be optimized if they are implemented on a trans-boundary level.

In keeping with the FWS Directorate's Conservation Principles, the group urged creative, innovative partnerships as well as establishment of working groups focusing on regional cooperation. A suggested example of an innovative partnership is the Circumpolar Biodiversity Monitoring Program (CBMP). The CBMP was developed by the Conservation of Arctic Flora and Fauna Program in response to a directive by the Arctic Council of Ministers for programs that promote the vital importance of biodiversity conservation, preservation of ecosystems, and sustainable development in the face of global change. The Circumpolar Program is an international network of key scientists and conservation specialists from nine Arctic countries with the goal of developing an integrated Arctic biodiversity

monitoring program.

Recommendations

- Establish additional climate monitoring stations.
- Expand baseline inventories and develop comprehensive databases.
- Learn from both traditional and paleo-environmental studies to determine possible future changes.
- Determine thresholds for indicator species.
- Take a proactive approach to outreach by seeking public support and buy-in.
- Host a regional ecological summit to reveal the state of ecological knowledge for the region.
- Develop partnerships to continue sharing information and strategies.
- Establish a web page with links to climate change information and current projects; make available to FWS employees.

Arctic EPU

Discussion Summary

The Arctic EPU group began their discussion by selecting the following categories of climate change effects based on their importance in the arctic, vulnerability to predicted climate change, and the expertise of the group: (1) arctic coastal plain aquatic ecosystems; (2) vegetation; (3) marine species; and (4) terrestrial species. The group completed the first three, but was not able to discuss terrestrial species in the time allotted. As with several other breakout groups, the group identified coordination with partners, predictive modeling, and mining existing data as common needs across these priority topics. The team agreed that the results of the discussion should be viewed as preliminary and cautioned that the species, species groups, or systems focused on do not represent the outcome of a formal prioritization process. One of the main overall recommendations was that such a process be developed to guide future research, monitoring, management, and outreach efforts.

Under arctic coastal plain aquatic ecosystems, the group discussed both coastal plain wetlands and nearshore aquatic systems. Nearshore was defined to include barrier island and lagoon systems, shallow continental shelf waters, and estuarine systems. The nearshore system has high importance for many species of migratory birds including common eiders, other waterfowl, and shorebirds. The group recognized that climate change is likely to enhance erosion at the land-water interface, increasing the risk of contaminant mobilization. Participants also acknowledged that climate change is likely to affect the overall productivity of the system and alter trophic relationships.

Arctic coastal plain wetlands have high importance for fish and numerous avian species, including Pacific brant, loons, and shorebirds. These wetlands are expected to be affected by hydrologic changes related to thawing of permafrost and changes in the relative contributions of precipitation and evapotranspiration to hydrologic balance. Similar to nearshore systems, the team recognized a critical need to identify species' distribution and abundance, and to monitor demographic trends.

The group also discussed vegetation changes, focusing on tundra habitats dominated by sedges and herbaceous species. Significant changes in arctic tundra vegetation are predicted, due to changes in hydrology, permafrost, soil moisture, soil temperature, and length of the growing season. Research needs include monitoring of plant species cover, including surveillance for invasive species, and an assessment of vulnerable habitat. The group recommended focusing vegetation monitoring efforts on riparian areas, which have high wildlife value. An often overlooked resource in studies of vegetation

change is historic data. Numerous studies that included assessment of plant species composition and cover have been conducted over the years. Many of these studies were not originally designed to contribute to long-term datasets, but they may provide useful data nonetheless.

Finally, the Arctic EPU focused on marine species, citing the threats of diminishing sea ice and increased levels of commercial activities and shipping traffic in the region. Reduced ice pack may lead to range expansion for pelagic species such as gray whales, orca, harbor porpoises and harbor seals, while populations of ice dependent species such as ringed and bearded seals, polar bears, and walruses are likely to decline. The group further narrowed their discussion to the Pacific walrus. As the ice edge continues to recede from the shallow continental shelf, the ability of walruses to feed will be increasingly impaired. The change in sea ice habitat will likely result in large changes in walrus distributions, and increased reliance on coastal haul out sites. Large aggregations of walruses in the near shore environment may result in local depletion of food resources and increased interactions with human activities. Research and monitoring needs include: (1) additional tagging studies to document distribution and movements, particularly in relation to the sea-ice edge; (2) evaluation of population status and trends, including reproduction, survival, and meta-population structure; and (3) identification of important feeding areas, particularly in the Chukchi Sea. Another important next step is harvest monitoring. Russia should be a primary partner in research and monitoring efforts.

Recommendations

- Coordinate remote sensing, modeling, and field studies to evaluate vulnerabilities of trust resources currently and in light of predicted ecosystem changes.
- Refine predictive models though an empirically based approach to inform prioritization of research and monitoring activities, and lead to more effective adaptive management.
- Enhance coordination between partners, including federal and state agencies, academia, NGOs, State of Alaska, Native communities, and Canadian and Russian colleagues.
- Develop a protocol to prioritize monitoring and research targets.
- Establish a mechanism to identify vulnerable, biologically important habitats, with the goal of protection.
- Develop accurate, fine-scale predictive models of habitat changes to predict species vulnerabilities, and to inform research, monitoring, and management priorities.
- Mine data: locate historic vegetation plots and repeat measurements.
- Develop decision support models for planning.
- Increase and improve network of weather stations and river gauges.

<u>Interior EPU</u>

Discussion Summary

The Interior EPU group looked at the effects of climate change from an ecosystem level, as opposed to focusing on a specific species within the selected areas of climate change impacts. A better understanding of landscape changes will give managers the best opportunity to adapt management to serve a greater number of fish and wildlife species. The group discussed types of information managers will need to identify and understand ecosystem changes before or as they occur. Participants also stressed the need for cooperative collaboration with partners in order to develop a successful climate change strategy.

Using the landscape level approach, the group selected three priority topics: changing wetlands (both

drying and expanding), increased fires, and impacts on fish. With respect to wetlands and streams, and the impacts of changing fire regimes, more information about water dynamics and plant community response to perturbations is necessary. More information is also needed on the interactions between subsurface, surface and atmospheric water in Interior ecosystems; additional physical parameter monitoring stations were recommended across the landscape. These stations should be coordinated with other monitoring projects underway, particularly the USGS Yukon River Basin Climate Effects Assessment and Benchmark Monitoring Plan. With regard to changing plant communities, more information is needed on plant community response to drought, temperature change, and fire. This should include a better understanding of the speed at which these communities will change as well as the magnitude of changes. Collectively, this information should lead to the creation of predictive models that will give managers lead time to plan for drying lakes, changing stream temperatures and fish populations, changing boreal plant communities, and focal areas (terrestrial and aquatic) that may need special protection or management. Predictive models of changes in fire occurrence and frequency relative to different climate change models are already available from University of Alaska, Fairbanks. Refuge-specific versions of these models are being created and will be available in 2008.

Finally, the group recommended this work be collaborative, involving partners within state and federal governments (such as Alaska Department of Fish & Game, National Park Service, and the USGS) as well as local governments (Fairbanks North Star and Denali Boroughs) and non-government organizations (University of Alaska, The Nature Conservancy). The group supported the idea of having coordinators at the agency level to improve communication and efficiency. In addition, the group strongly recommended that discussions between the Service and the Yukon River Basin Assessment and Monitoring Plan begin immediately to better combine efforts and seek funding using a mutually agreed upon approach.

Recommendations

- Coordinate with other monitoring projects underway, such as the USGS Yukon River Basin Climate Effects Assessment and Benchmark Monitoring Plan.
- Establish more stream monitoring stations.
- Develop predictive models that will give managers lead time to plan for ecosystem changes.
- Work collaboratively with partners such as ADF&G, NPS, BLM, USGS, and EPA.
- Create regional climate change coordinator positions at various agencies (FWS, NPS, BLM, and USGS) to improve communication and efficiency.

<u>South Central EPU</u>

Discussion Summary

The South Central EPU group discussed the general climate change impact of species movements, using invasive species as the focal group, and the impact of vegetation shifts, using wetland drying/habitat conversion as the focal habitat. Like the participants in the Interior EPU, this group stressed that using a large-scale, landscape approach to climate change impacts is essential for successful management. For invasive species, the group reached a consensus about the management goals for this impact and the discussion moved to specific strategies for meeting that goal. However, no consensus about an appropriate management goal emerged for wetland drying and the discussion focused on information needed in order to define a goal that meets agency mandates.

The group agreed that invasive species spread should be minimized, assuming that maintaining

regional species assemblages is important for conservation. Invasive species were defined as those that move into areas through human vectors (transplantation) and not species that are moving north due to climate change. The South Central EPU is particularly vulnerable to an accelerated spread of invasives due to the road network, trail networks, and floatplane access. Climate change has the potential to further exacerbate the problem as it may allow the establishment of invasive species that were limited in the past by winter temperatures or other climatic factors.

After discussing invasives, the South Central EPU focused on the impacts of wetland drying. On the Kenai Peninsula, wetland drying has been documented along with black spruce and shrub encroachment. The topic led to a discussion of whether this type of habitat change should be allowed to progress unhindered or managed; this in turn led to the larger question of whether, in response to climate change, the Service should adopt a strategy of adapting or mitigating effects. Since the group was split between these choices, they did not reach a conclusion. They suggested that changes in wetland distribution and area across Alaska must be understood before the agency chooses a direction.

In spite of this inability to reach a conclusion, the group discussed potential scenarios in response to wetland drying. If wetland habitat were increasing in other regions of Alaska or within the EPU, then it would be appropriate to allow this type of habitat conversion. The group agreed that the difference between long-term and short-term management solutions is important for planning. For example, some intensive management actions like habitat manipulations or species translocations might be possible in the short term to allow species time to react to rapid habitat change. However, in the long-term it may be impossible to stop directional ecosystem changes (i.e., to maintain current landscape composition and structure) under scenarios of climate change, barring large-scale manipulations.

Recommendations

- Partner with other federal, state, and local agencies to minimize exotic/invasive introduction and spread using current management practices.
- Increase inventory and monitoring of invasive species; prioritize critical species to control and geographic areas susceptible to invasion.
- Eradicate invasive species in the most ecologically sustainable way.
- Partner with federal, state, and local agencies and NGOs to educate the public about invasive species.
- Research “best management practices” for preventing the spread of invasives, particularly in Hawaii and California.
- Use a large-scale, landscape approach to managing climate change impacts.

<u>South Coastal EPU</u>

Discussion Summary

The South Coastal EPU breakout group selected the marine environment and vegetation changes as its priority issues. The group did not have time to discuss salmon, but that should not imply a judgment about its important role in the region. The group highlighted themes similar to those explored in other EPU working groups, such as reviewing existing data with respect to climate change and identifying data gaps, working with partners on climate change efforts, and appointing a regional climate change coordinator. Before considering the decision framework, team members discussed changes already apparent in the South Coastal EPU that may be related to climate change, such as glacial retreat, a decrease in annual snow level, and changes in alpine habitats.

In the marine environment, potential effects of climate change include tidewater glacier retreat, freshwater input, and changes in sea surface temperature. The group narrowed the marine environment to seabirds and, after much debate, focused on the pigeon guillemot due to declining numbers in Prince William Sound. Potential research and monitoring needs include understanding the effects of climate change on forage species, seasonal movements, and population trends outside the EPU.

After the marine environment, the group focused on vegetation changes. Potential threats as a result of climate change include shifts in distribution and abundance, increased herbivory by introduced species, and increased insects, pests, and disease. To better understand vegetation changes, common land cover maps are needed, as well as long-term monitoring plots to monitor change in disturbed areas, high resolution photographs for detailed analyses, and a standardized methodology for classification among all refuges and other landowners. The group identified many potential partners for both seabird research and vegetation monitoring, ranging from ADF&G to the Forest Service to the National Park Service.

Recommendations

- Appoint a regional climate change coordinator.
- Identify existing data and what classification systems are useful for monitoring effects of climate change.
- Work with partners on climate change efforts.
- Develop a monitoring strategy with long-term plots to compare existing with future conditions, specifically with vegetation research.
- Institute standardized vegetation mapping and classification for refuges.
- Develop better digital orthophotography at a 1:24 scale.
- Charter an inter-agency climate change working group to continue discussions and sharing of knowledge.

Western EPU

Discussion Summary

The Western EPU Team focused primarily on a single ramification of changing climate: the impact of changes to wetlands (both gains and losses) on waterfowl nesting habitat. Specifically, waterfowl are being impacted by the loss of wetlands through both coastal erosion and wetland drying, leading to increased predation, and decreasing populations. Although the group made a focused effort to narrow the scope of the issue to a manageable level from which meaningful recommendations would emerge, the complexity of the situation became increasingly apparent as the discussion progressed. Thus, the resulting recommendations are not specific action statements, but instead are generalities that apply equally well to other issues. Many partners were suggested to help with additional research, including the Waterfowl Conservation Committee, Yukon Watershed Council, local villages, NGOs, and the NPS. Similar to the South Central EPU, this group also debated the merits of the Service either working with or against climate change impacts.

The group then followed the decision framework on a different issue, the status of eelgrass in western Alaska, and found that the process took them to a similar set of general recommendations. After some discussion, the group concluded that it did not have sufficient time or information to make more specific recommendations. Participants then brainstormed recommendations from a broader standpoint,

rather than follow the framework provided. One broad recommendation was to perform a more thorough information needs assessment, including a knowledge gap analysis, relative to the impacts of changing climate on the Service's management agenda. The group suggested using an established decision process, such as the Analytic Hierarchy Process, which the FWS Alaska Region has already used successfully on fishery information needs.

Recommendations

- Synthesize historic and current existing information on changing wetlands and identify the data gaps.
- Continue to inventory and monitor wetland gain/loss to fill data gaps.
- Develop a predictive model/risk analysis to forecast continuing changes.
- Based on information collected on wetlands, take action as appropriate.
- Monitor physical processes that may be affected by climate change by establishing a larger stream gauging network in Alaska.
- Improve the quality of mapping capability and products for the Western EPU.
- Enhance the collaborative network among conservation units across Alaska to provide needed inventory data.

THEMATIC BREAKOUT SUMMARIES

Framework for Discussions

During the second day of internal meetings and final day of the Forum, USWFS and USGS employees were asked to break out into different groups to focus on broad themes in relation to climate change. Each group was given a general background and suggested questions to get them started. The original topic is summarized, followed by a summary of the discussion and recommendations. Similar to the EPU working groups, the conversations and recommendations varied in scope.

Inventory & Monitoring

Task

The FWS has an extensive inventory and monitoring program; several hundred surveys are conducted annually and biannually by Refuges alone. These long-term data sets are invaluable in making management, conservation, and use decisions across the Service's wide array of responsibilities and trust resources. However, inventory and monitoring plans often have little programmatic or geographic integration. The effects of climate change on Alaska flora and fauna are predicted to be far-reaching, and the Service's ability to modify its management objectives and strategies in response to these changes may require a reconsideration of current inventory and monitoring efforts. This discussion group addressed how the Service's inventory and monitoring program can remain adaptive while still providing valuable scientific data to other programs.

Discussion Summary

Recognizing that climate change is a broader issue than can be addressed just at the refuge or state level, the inventory and monitoring group recommended better communication among stakeholders, land owners and other partners; identifying existing data outside of the FWS; and the formation of EPU working groups assigned specific inventory and monitoring tasks. Suggested examples of integrated datasets the Service might examine included the US Forest Service's comprehensive Natural Resource Information System (NRIS), which integrates and analyzes diverse datasets that can be shared across Forests; and the National Ecological Observatory Network (NEON), a platform created by the National Science Foundation intended to answer regional and continental scale scientific questions through interdisciplinary participation.

The team also suggested using the EPU format to create inventory and monitoring focused working groups within the FWS. The EPU working group goals would include: 1) Identification of stakeholders, inviting participation and coordination, with a strong emphasis on communication and partnerships; 2) Coordination with other EPU working groups to develop a common process to survey stakeholders for existing, relevant climate change data and information, including methods for information management; 3) Identification of existing datasets or data mining - what other ongoing projects or programs exist that would be relevant to climate change, and would help build partnerships? 4) Identify data gaps and needs, and subsequently collect baseline information such as landcover/habitat information and digital elevation models; 5) Move quickly on some actions, including partnering with the USGS Yukon Basin project, making a presentation at the July Regional Directorate meeting, and developing a FY09 budget.

Central to the success of the EPU groups in the FWS would be the appointment of a regional climate

change coordinator. The working groups would also need a framework to guide coordination between the EPUs, other agencies, the directorate, and perhaps nationally, as well as a process through which to implement subsequent recommendations.

Recommendations

- Hire a regional level climate change coordinator for the FWS, and ideally the USGS.
- Form EPU working groups with specific climate change inventory & monitoring goals. Groups would:
    - Coordinate with geographic partners;
    - Develop a common process among EPU groups to collect existing information;
    - Search and assess existing information;
    - Identify data gaps and needs.
- Develop a conceptual framework for directing inventory and monitoring efforts on both a landscape and local scale.
- Partner with the USGS Yukon River Basin Climate Change Assessment project.
- Develop a budget for FY09 to address inventory and monitoring needs with respect to climate change.

Addressing Climate Change Through the Planning Process

Task

In 2005, the FWS and the USGS met to identify the most important emerging challenges to conservation of biodiversity and ecosystem function in Alaska. The resulting Future Challenges Project report recommended that the Service's Alaska Region incorporate climate change management into all strategic planning processes. At the Climate Change Forum, the planning breakout group was asked to identify priority planning issues and options to help the Region adapt to managing trust resources in the face of a changing climate.

Discussion Summary

The planning group emphasized that collaboration among Service programs and with partners, and having future ecological predictive models that the public and partners will trust, are essential to successful planning. Collaboration is vital to addressing climate change because it is not an isolated event but a continual process that affects all regional programs and partners. Regional programs must collaborate to maximize efficiency and avoid duplication of data gathering efforts. The Service should partner with local, state, and federal climate change assessment efforts, such as the USGS Yukon Basin Climate Change Assessment project.

Planning efforts across the Region would be strengthened through the use of non-Service climate change scenarios that predict future ecological changes. USGS ecological change models developed at the EPU level could provide a range of climate-related scenarios to predict future, on the ground conditions. The USGS is currently working with models that provide regional scale and scenarios for Alaska that would be useful to the FWS. Additionally, the Service could help USGS improve these models by providing local soils, moisture and vegetation data.

Finally, Regional planning efforts to address climate change would be vastly improved by Regional oversight, support and coordination. Additionally, establishing cross-programmatic EPU teams would

be beneficial. A Regional level climate change coordinator within the FWS could facilitate and coordinate EPU teams, as well as coordinate communication between agencies. The FWS coordinator would be responsible for ensuring Service plans included climate change factors and establishing consistency across plans and management decisions. The regional coordinator would also be helpful in facilitating outreach and communication both internally and with partners, particularly by providing annual updates on climate change research, maintaining a central website with information and links to ongoing projects, and facilitating staff communication.

Recommendations

- Partner with local, state, and federal climate change assessment efforts.
- Either develop, or use existing, non-Service predictive models for climate change.
- Hire a regional level climate change coordinator responsible for facilitating staff and information sharing.
- Establish cross-programmatic EPU teams.
- Create a central website and clearinghouse for climate change information and research.

Natural Diversity

Task

Title III of ANILCA describes the purposes of National Wildlife Refuges in Alaska. The first of these purposes is to: (i) "Conserve fish and wildlife populations and habitats in their natural diversity…" The term "natural diversity" is not defined by ANILCA, nor has it been defined by the Service. Given the current understanding of the effects of climate change on Alaskan ecosystems, changes in the distribution and abundance of species throughout the region are expected. In order to conserve species in their natural diversity into the future, there must be a definition of natural diversity to guide management. This breakout group discussed the term "natural diversity" and the Service's role in managing for it in the context of climate change.

Discussion Summary

Members of the natural diversity group initially described their own definitions of natural diversity and identified components that were important in a potential definition. In order to define natural diversity there needs to be a common understanding of spatial and temporal scales, clear differentiation between non-native invasions (as defined in EO 13112) and range extensions, and agreement on how the Service will respond to ecological processes that are resulting from accelerated climate change.

Spatial scale can influence the perception of how natural diversity is impacted by accelerated climate change. The Service may respond to changes in natural diversity differently if it is looking within a single unit's boundaries, such as a refuge, as opposed to looking at natural diversity from a statewide or global scale. Temporal scale can also influence the perception of how natural diversity is impacted by accelerated climate change. Natural diversity will change through time even without anthropogenic climate change drivers. The group agreed to define a short timescale of 50 years and a long timescale of 300 years, but agreed that a set timeframe warrants further discussion.

The group focused on two different scenarios – changes in ecological processes in response to climate change considered as "natural" or "unnatural" - and discussed the implications of both approaches. For each scenario, the group brainstormed possible management actions, research and outreach

opportunities, as well as potential positive and negative aspects of these management actions. In both scenarios, suggested management actions included inventorying existing conditions; using strategic land acquisition/partnering to provide for movement corridors at different spatial scales; accepting a local loss of species within its changing species-wide distribution; informing the public about how shifts in species and natural processes may occur; and continuing to aggressively deal with exotic, invasive species. The differences between the scenarios were related to the rate of change in communities/species/population, the status of populations when the Endangered Species Act might apply, and the difference in the level of active management of those processes where humans have some control. The assumption that changes in ecological processes in response to climate change are "not natural" would be the more conservative, precautionary approach until natural diversity policy is established.

A third scenario was a variation on accepting changes as "natural." Under this scenario, the Service would be proactive in managing changes. Through strategic planning and coordination the Service might encourage the anticipated shifts in habitat types to occur in a more predictable manner. For example, the Service could aggressively translocate wildlife species to areas that have experienced changes in vegetation that are suitable for these species but that are isolated from extant populations. This proactive management in response to accepting climate change as "natural" was not discussed in the breakout session, but should be raised in further discussions.

Finally, the natural diversity group created a detailed list of types of information deemed necessary to take action on climate change. These included summarizing existing data; collecting more physical parameter data using weather, hydrology and air quality monitoring stations; developing predictive models; identifying and ranking the risk of species going extinct and the ecological consequences of that species loss; using paleoecology to look back through time to see how species responded to climate changes of the past to improve future predictions; and monitoring parasite/diseases and population response to a warming climate.

Recommendations

- Establish FWS regional policy for Alaska to manage natural diversity into the future.
- Develop Alaska policy statement for conserving natural diversity in the context of climate change.
- Summarize current international monitoring and land partnering initiatives already underway. How can FWS efforts complement ongoing programs? The goal should be to identify opportunities to partner with larger-scale inventory & monitoring efforts, and to partner in larger-scale land conservation and corridor establishment.
- Consider identifying a National Wildlife Refuge as a case study for conducting a cost-benefit analysis of inventory and monitoring needs, and implementing different management strategies for natural diversity in response to climate change.
- Make climate change information available on a website. Link the Climate Change Forum website to other climate initiatives, specifically assigning maintenance of the site.
- Identify priority predictive models – write problem statement, pursue partners.
- Emphasize the importance of weather, hydrology, and air quality monitoring data and expand these stations.
- Management actions:
    - Inventory existing conditions;
    - Use strategic land acquisition/partnering to provide for movement corridors at different spatial scales;

- Accept a local loss of species within its changing species-wide distribution;
- Inform the public about how shifts in species and natural processes may occur;
- Continue to aggressively deal with exotic, invasive species.

Alaska Case Study

Task

The Strategic Plan of the US Climate Change Science Program (CCSP) calls for the preparation of 21 Synthesis and Assessment Products to support policy making and adaptation decisions across a range of climate change issues. The EPA has responsibility for the preparation of several of these products, including one entitled "*Preliminary Review of Adaptation Options for Climate Sensitive Ecosystems and Resources.*" For selected ecosystems, this report will identify: climate sensitive management goals, options for adapting to climate change, and action opportunities and limitations. The report will examine ecosystems or resources in six federal management systems; Alaska has been selected as a case study for the National Wildlife Refuge System. Case studies will be used to illustrate implementation of specific adaptation methods and how they may be applied to other ecosystem types or geographic regions with similar goals and climate change stresses. This breakout group helped answer these questions with respect to waterfowl and wetlands within Alaska's National Wildlife Refuges (NWR).

Discussion Summary

The case study group focused on adaptation options for wetlands and waterfowl in Alaska. The group considered the following topics: examples of recent climate change related challenges and adaptations in Alaska; appropriate response levels to climate change; conservation targets and their function; opportunities for and barriers to adaptation; and management tools needed to adapt to climate change.

The group identified examples of recent climate change-related challenges and adaptations in Alaska, such as lake drying and changing snow conditions affecting perception of access to subsistence resources in Interior NWRs. The Service adapted by promoting enhanced capacity for predicting possible future conditions while educating clients regarding observed and expected changes; clarifying potentially conflicting information; and cooperating with multiple partners. This and other examples emphasize that successful adaptation to climate change is possible. The team pointed out that the FWS has faced and overcome previous crises such as market hunting, the Dust Bowl, and threatened and endangered species; with an emphasis on prediction, planning, and adaptation, and a reminder of past successes, the group believed the FWS should be able to energize a successful response to the fourth National Wildlife Refuge System crisis of climate change.

Further, the group recommended that responses to climate change challenges occur at integrated levels within the National Wildlife Refuge System and with partner entities. Individual symptomatic challenges of climate change must be addressed at the refuge level, while systemic challenges must be addressed at a broader level. If Flyway Councils can be encouraged to include a regular focus on climate change, they may provide an essential mid-level integration mechanism. Regardless of the level of response, the immediate focus needs to be on achievable actions.

Due to the uncertainty associated with climate change, conservation targets must not be static. Refuges with broad mission statements, such as those created through ANILCA, will have the greatest

flexibility to accommodate future change in species composition, whereas refuges charged with protecting threatened and endangered species will face the greatest challenges. There is a clear need to produce national and regional assessments that identify ecosystems, and to use this information for proactive conservation target planning. The function of conservation targets should be to provide a sufficient, representative, resilient and redundant sample of trust species and groups that will provide minimum viable populations as well as recreational and subsistence opportunities where appropriate.

The team created a list of necessary management tools to address climate change, including: long term national level planning and collaboration with other federal land management agencies, NGOs and private stakeholders; increased capacity to model possible future conditions; an efficient climate change communication network; national and regional coordination mechanisms; and the ability to integrate potential climate effects into management decisions.

Finally, the group discussed opportunities and barriers to adaptation to climate change. Specifically, opportunities included designing inventory and monitoring programs to enhance detection of climate change effects, particularly changing distributions, and increasing coordination with partner groups. Some suggested barriers to adaptation were a lack of spatially explicit information regarding climate effects on life cycle stages of migrants, lack of adequate resources and funding mechanisms for all activities, and internal inertia.

Recommendations

- Hire a climate change coordinator at the regional level within the FWS.
- Develop an efficient climate change communication network; *ad hoc* communication is inadequate.
- Increase capacity to develop predictive models.
- Formalize climate change as part of Flyway Councils.
- Institutionalize climate change in FWS job descriptions.
- Increase awareness about the role of climate change throughout the Service, possibly via trainings and forums.

Species of Conservation Concern

Task

Six species managed by the Service are currently protected under the Endangered Species Act (ESA) in Alaska, but climate change may increase the number of species at risk. For example, the Service recently proposed listing the polar bear as a threatened species, largely due to the retreat of sea ice. Additionally, there are dozens of species listed as species of conservation concern. A recent synthesis of climate impacts in the Arctic identified a broad array of anticipated changes, such as a reduction in sea ice that will affect ice-associated species, vegetation changes that will alter food sources for ungulates, & northern shifts in species' ranges that will bring new species or further limit ranges of some taxa. This breakout group considered these types of impacts on populations already at risk, and addressed questions such as how to prioritize species for conservation.

Discussion Summary

After an initial, wide ranging discussion, the first topic the group discussed was whether the Service should identify species of conservation concern lists based on climate change effects. Many types of

lists exist, such as World Conservation Union (IUCN) red list of endangered species, which are integrated and available through NatureServe. Data and information from these existing categories could be used to create a ranking of species most vulnerable to climate change, whether because of loss of habitat, a reduction in prey species, or due to the species' limited range. The purpose would be to establish a broad sense of the vulnerability of the Service's trust species, which would inform better management and planning decisions. The group arbitrarily selected a 50-year time scale, while recognizing that further consideration of such a timeframe is necessary. Such a list could also be a useful outreach tool. Ultimately the team decided on a simple grouping into three categories: red - species of urgent concern; yellow – species with 50 year concerns with unknown links to climate change; and green - species that may benefit and/or there is no clear effect of climate change.

The group also discussed the integration of subsistence harvesting responsibilities with the responsibility of managing species of conservation concern, primarily using the walrus as an example. However, participants did not reach definitive conclusions or recommendations and the conversation shifted to other topics. The final question the group addressed was whether the Service can help drive potential changes to existing legal mandates: how would changes to regulations help achieve better species conservation given the threat of climate change? Currently, neither the ESA nor the Marine Mammal Protection Act (MMPA) includes a "pre-depletion" trigger that would allow the Service to begin managing for a decline in population before a species faces serious threat. For example, it is very difficult to get a reliable population estimate of walruses that would withstand the scrutiny of the ESA. A broader concern was how to manage for species that are threatened (perhaps doomed) with extinction – should the Service spend its limited funding on them? What would be the public reaction toward the Service not actively stepping in and managing a declining species? The discussion largely revolved around the need for flexibility and an ability to take action earlier in the absence of absolute data. Birds, walruses, polar bears and goshawks were the main species considered.

Recommendations

- Rank the species of conservation concern, high, medium, or low, based on climate change.
- Identify ways to bring other experts in to address the data gaps.
- Recommend policies or actions that allow for more flexibility in taking conservation actions.
- Pursue agreements that protect/conserve habitat the shared species will inhabit in the future based on climate change trends.
- Shift MMPA & ESA policy to manage for climate change and allow earlier actions.
- Increase efforts for early conservation strategies, before species have to be protected under MMPA and ESA.
- Recognize that lack of data is a chronic, limiting factor, especially in the context of climate change, which makes advanced decisions challenging, requiring increased flexibility and other approaches to decision making.
- Link with partners.

FEEDBACK ON THE FORUM

Forum Structure

The Climate Change Forum for Alaska was organized into four different components. The first day included technical presentations from scientists conducting research on climate change across the region. Presentation topics included an overview of climate change in the Arctic; changes to Alaskan permafrost; effects of climate change on terrestrial and marine mammals; and perspectives of indigenous Alaskans on climate change, among others. The second day included an overview of Fish & Wildlife Service mandates, which was intended to provide context for the breakout discussions.

After the mandates overview, FWS and USGS employees broke into groups based around Ecological Planning Units (EPUs). Each EPU team was provided a matrix to help the team brainstorm climate change effects and organize them in a consistent, logical manner. Groups were asked to select from a list of climate change effects, such as species movements or increasing fires, which was adapted from *ACIA, Impacts of a Warming Climate: Arctic Climate Assessment (2004)*. The purpose was to generate discussion and was not meant to be construed as determining factors; the topics were intended to be a beginning point. Other relevant topics may have been missed, and participants were encouraged to identify additional issues. After selecting a topic, group members worked through each topic identifying needs for research, outreach and partnership opportunities, and next steps, among others.

On the final day of the Forum, participants broke into thematic groups and held less structured, broader discussions. Themes included inventory and monitoring, species of conservation concern, and natural diversity. Each group was given background information on the topic and provided a list of questions to start the discussion. Following the EPU and thematic breakout sessions, group leaders presented a summary of their group's discussion and recommendations to all Forum participants. Group leaders were also tasked with providing workshop organizers with a summary of their group's discussions and conclusions, for inclusion in this report.

Feedback

The initial day of presentations, and the poster session afterward, generally received very positive feedback. If anything, participants would have liked more time for questions and answers, and discussion, following the presentations. The research provided excellent background information on the effects of climate change in Alaska, even for those who were already familiar with many of the effects. For some attendees the presentations were as informative as they were inspiring. The attendance of the national directors of both the FWS and USGS also lent weight to the importance of the issue. The poster session provided FWS and USGS employees the opportunity to share research ideas and results related to climate change with their colleagues.

Overall, for the breakout discussions many participants expressed concern that the issues chosen for discussion did not necessarily represent the highest priorities; rather, they represented what was manageable given the limited time available and the composition of the groups. All agreed that the Forum served as a valuable launching pad for further internal and external conversations and actions addressing climate change in Alaska.

The matrix used for brainstorming climate change effects received mixed feedback. The matrix was intended as a way to help participants think about problems in a consistent, logical manner. Most

groups had few problems using the format, but some had difficulties. A primary problem across groups was whether to focus on a particular species or an ecological process. Whether a species or process was chosen affected the group's outcome and recommendations. In many cases, which effect or focus was selected depended on the composition of the group; if a group had an expert on a topic, that topic was more likely to gain attention. Additionally, the outreach section of the matrix frustrated some participants because it lacked specificity, which often led to very broad recommendations.

Groups in which the team leaders came prepared with previously identified topics for discussion fared better when using the matrix. In at least one group, team members communicated prior to the breakout session to discuss ideas. If all groups had communicated beforehand, the teams may have been more successful and better prepared to make more creative or innovative recommendations. Some participants expressed disappointment in the very general recommendations that emerged from the Forum. Others felt that this was a reasonable expected outcome given the daunting nature of the climate change problem, and that general discussion and recommendations are a necessary prequel to more targeted discussions and specific recommendations.

Also essential to a team's success was the ability of the leader to guide discussion. While it was helpful for a leader to have identified topics prior to the meeting, it was equally important that he or she incorporate group feedback. Uncertainty about the outcome of the recommendations may have affected the discussions. For many participants it wasn't clear how, or whether, their team's recommendations would be used in the future. A clear understanding of how the results of the Forum will be used would likely encourage broader thinking. For example, if participants knew the EPU format would be carried on in future working groups, as was widely recommended during the discussions, it may have helped the discussion. Additionally, some participants felt the forum should have been made a priority for all Region 7 employees; required attendance may have led to more appropriate group facilitators in some cases. Finally, many participants were energized by the more open-ended thematic discussions on the final day; the primary suggestion was a request for more time to discuss the important issues.

Recommendations

- Group leaders should spend time prior to the meeting to identify key issues in the EPU with input from other participants.
- Group leaders may want to organize a pre-workshop meeting or conference call to solicit ideas from all team members.
- Facilitators and group leaders should be involved in the planning process as early as possible to ensure clear expectations and familiarity with the discussion process.
- The matrix may work better if only one or two examples are tackled during the breakout sessions. Additional options include longer or multiple breakout sessions.
- This forum was organized and implemented by Region 7 FWS and USGS employees on a volunteer basis, and required significant sacrifices to their current positions. If such a forum is held again, it would be helpful to identify a climate change coordinator prior to the forum. Having a coordinator in place would ensure many of the recommendations would be carried forward more quickly and thoroughly.
- All employees should be required to attend any similar forum in the future.

Footnotes

[1] IPCC, 2007. *Climate Change 2007: The Physical Science Basis. Summary for Policymakers.*

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[3] Inkley, D. B., M. G. Anderson, A. R. Blaustein, V. R. Burkett, B. Felzer, B. Griffith, J. Price, and T. L. Root. 2004. *Global climate change and wildlife in North America*. Wildlife Society Technical Review 04-2. The Wildlife Society, Bethesda, Maryland, USA. 26 pp.

[4] ACIA. 2005. *Arctic Climate Impact Assessment – Scientific Report.* Cambridge University Press, 1042 pp.

[5] ACIA. 2004. *Impacts of a Warming Arctic: Arctic Climate Assessment.* Cambridge Univ. Press. 145 pp.

APPENDIX 1

Selected examples of ongoing climate change research efforts and other resources (such as past studies or integrated data examples) outside the U.S. Fish & Wildlife Service that were referenced during the EPU and Thematic Breakout Groups at the Climate Change Forum for Alaska, 2007.

Resources for Information on Climate Change

Arctic Climate Impact Assessment (ACIA)

- An international project of the Arctic Council and the International Arctic Science Committee (IASC) to evaluate and synthesize knowledge on climate variability, climate change, and increased ultraviolet radiation and their consequences. The results of the assessment were released at the ACIA International Scientific Symposium held in Reykjavik, Iceland in November 2004.

The Center for Global Change and Arctic System Research

- The Center for Global Change and Arctic System Research was established in March 1990 to serve as the focal point at the University of Alaska Fairbanks for developing, coordinating and implementing interdisciplinary research and education related to the role of the Arctic and sub-Arctic in the Earth system, and to stimulate and facilitate global change research in this region.
- The site includes links to other projects such as the Cooperative Institute for Arctic Research.

Global Terrestrial Observing System (GTOS)

- The Global Terrestrial Observing System is a program for observations, modeling, and analysis of terrestrial ecosystems to support sustainable development.
- GTOS facilitates access to information on terrestrial ecosystems so that researchers and policy makers can detect and manage global and regional environmental change. GTOS is one of the three main observing systems that contribute to the Global Climate Observing System (GCOS).
- The site includes many links to other ongoing efforts, as well as several publications.

Intergovernmental Panel on Climate Change (IPCC)

- The Intergovernmental Panel on Climate Change (IPCC) was established by WMO and UNEP to assess scientific, technical and socio- economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation. It is currently finalizing its Fourth Assessment Report "Climate Change 2007". The reports by the three Working Groups provide a comprehensive and up-to-date assessment of the current state of knowledge on climate change. The Synthesis Report integrates the information around six topic areas.
- The site includes extensive links to climate change research and past IPCC publications.

Climate Change Initiatives (past & present)

The Boreal Ecosystem Atmosphere Study (BOREAS)

- The Boreal Ecosystem-Atmosphere Study (BOREAS) was a large-scale experiment initiated in 1990 to investigate interactions between the boreal forest biome and the atmosphere. Surface, airborne, and satellite-based observations were collected to study the biological and physical processes and conditions that govern the exchanges of radiative energy, water, heat, carbon, and trace gases between boreal forest ecosystems and the atmosphere, particularly those processes that

may be sensitive to global change. Data were collected at representative sites in the boreal forest of central Canada from 1993 through 1996.

The Global Observation Research Initiative in Alpine Environments (GLORIA)

- Rapid climate change disproportionately threatens biodiversity of alpine ecosystems. GLORIA is an international research network to assess climate change impacts on mountain environments. It establishes a long-term observation network to obtain standardized data on alpine biodiversity and vegetation to assess the risk of biodiversity losses and vulnerability of high mountain ecosystems under climate change pressures. The first GLORIA site in the North American Arctic will be established this July in Selawik NWR.

USGS Yukon River Basin Benchmark Monitoring Plan and Assessment

- The USGS, WRD National Research Program (NRP) and the Water Discipline at the Alaska Science Center have been cooperating to collect baseline and process-based water quality data in the Yukon River Basin (2001-2005) as part of a research-based NASQAN study to understand the Basin's response to climate change. Climatic warming of the Yukon River Basin is resulting in lengthening of the growing season, melting of permafrost, and deepening of the soil active layer. These and related processes are anticipated to result in changes in water and sediment chemistry and discharge in upcoming decades. A better understanding of baseline trends and processes controlling the water quality of the Yukon River and its tributaries will facilitate the proper management of resources as conditions change in response to environmental change. As a first step in understanding these changes, the USGS is monitoring water discharge and making water and sediment chemistry measurements on the Yukon River and all of its major tributaries.
- Informational handout on the project in pdf form.

U.S. Climate Change Science Program (CCSP)

- The Climate Change Science Program integrates federal research on climate and global change, as sponsored by thirteen federal agencies and overseen by the Office of Science and Technology Policy, the Council on Environmental Quality, the National Economic Council and the Office of Management and Budget.
- The website is a bit challenging to navigate, but it includes a good library of climate change documents.

Examples of Integrated Datasets outside the FWS

National Ecological Observatory Network (NEON)

- The purpose of NEON is to be the first national ecological measurement and observation system designed both to answer regional- to continental-scale scientific questions and to have the interdisciplinary participation necessary to achieve credible ecological forecasting and prediction. The goal is to transform the way science is conducted by enabling the integration of research and education from natural to human systems. It is funded by the National Science Foundation.

US Forest Service Natural Resource Information Service (NRIS)

- NRIS combines a standard corporate database and computer applications designed to support field-level users. Databases contain basic natural resource data in standard formats built to run within the Forest Service computing environment. This system provides employees, our partners, and the public with access to essential natural resource data needed to support the management decisions that form the core business of the Forest Service.