

1 CHAPTER 5. NATURAL SYSTEMS

2 The Natural Systems sector addresses the observed and projected impacts of climate change on Alaska's
 3 ecosystems and the services they provide, and recommends priority adaptation actions that the State of
 4 Alaska should take to address the impacts and vulnerabilities associated with these impacts. Box 5-1
 5 summarizes the mission statement for the sector.

Box 5-1. Natural Systems Sector Mission Statement

Sustain natural ecosystem services in Alaska that meet society's essential needs, through adaptation to changing environmental conditions.

Overview of Natural Systems Options		
	Option Name	Level of Support
NS-1	Fisheries Management	Unanimous
NS-2	Wildland Fire Management	Unanimous
NS-3	Freshwater Management	Unanimous
NS-4	Invasive and Eruptive Species Prevention & Response	Unanimous
NS-5	Adaptive Fish & Wildlife Management	Unanimous

6

7 Impacts and Vulnerabilities

8 Alaskans (as well as humans across the globe) benefit from a multitude of resources and processes supplied
 9 by natural ecosystems. Collectively, these benefits are known as **ecosystem services** and they include
 10 products upon which humans depend, such as clean drinking water, timber, habitat for fisheries and wildlife,
 11 and pollination of native and agricultural plants. Natural ecosystem services can be *provisioning* such as the
 12 production of food, clean water, fiber and energy; *regulating*, such as the control of climate and disease;
 13 *supporting*, such as nutrient cycling, water purification and plant pollination; *cultural*, such as spiritual and
 14 recreational benefits; and *preserving*, such as maintaining ecological diversity and the resilience and stability it
 15 brings.

16 In the past three decades, Alaska has warmed at a rate approximately twice the global average, and
 17 additional warming of 4-7° C is projected over the next 100 years. Rapid warming has substantially affected
 18 Alaska's marine, terrestrial and freshwater ecosystems (ACIA 2004). The resilience and ecological integrity of
 19 these ecosystems varies, depending on the sensitivity of the physical environment to warming and the
 20 capacity of the current dependent-species to adapt or move in response to environmental changes. Warming

1 also brings the arrival of new species (including invasives) that can modify natural ecosystems in ways that
2 challenge their resilience to environmental change.

3 Key impacts and vulnerabilities for the natural systems sector include:¹

4 **Marine Ecosystems:** The seas around Alaska are responding to warming in ways that substantially influence
5 circulation patterns, sea ice, food webs and productivity regimes. In addition, independent of the effects of
6 warming, carbon dioxide from human emissions is causing about a 30% increase in the acidity of the oceans
7 worldwide, an effect projected to increase substantially by the end of this century. Impacts will be significant
8 in the Arctic Ocean, Bering Sea and the Gulf of Alaska, including changes in fish and wildlife species'
9 diversity, ranges, distribution and abundance; elimination of some species from Alaskan seas; introduction of
10 new species (including invasive species and pathogens); and loss of habitat for sea-ice-dependent species.
11 Alaskans will face impacts to commercial, subsistence and sport fisheries; changes in traditional modes of
12 travel, fishing and hunting in areas historically covered by sea ice; and other effects. Communities and
13 industries reliant on marine-based fisheries will be particularly affected, as will individuals and communities
14 dependent on subsistence harvest of marine fish and wildlife as essential elements of their food supply and
15 cultural well-being (ACIA 2004, Anderson et al. 1999, Brodeur et al. 1992, Grebmeier et al. 2006, Hunt et al.
16 2002, Sarmiento et al. 2004).

17 **Terrestrial Ecosystems:** Although effects will vary in different regions of the state, Alaska's terrestrial
18 ecosystems are generally expected to experience warmer and drier conditions with climate change. Thawing
19 permafrost and increases in the active soil layer will alter the hydrologic regime. In Southeast Alaska,
20 changing seasonality is expected to shift temperatures across the freezing threshold, significantly impacting
21 the amount of precipitation that falls as rain vs. snow and impacting ecosystem water availability. Vegetation
22 zones in Alaska are likely to shift, with tree line moving northward and to higher elevations, and forests
23 replacing a significant fraction of existing tundra. Animal species' diversity, ranges, distribution and abundance
24 will change, with new species arriving (including invasives) and some current species no longer able to thrive.
25 Impacts of warmer and drier conditions may include increased area and frequency of wildland fire, increased
26 insect outbreaks, retreat of inland glaciers, decrease in the area of continuous and discontinuous permafrost
27 and lakes, and an expanded growing season. These potential changes – some negative, some beneficial –
28 will substantially affect a wide range of human uses of terrestrial resources, including forestry and subsistence
29 harvest of fish and wildlife (ACIA 2004, Werner et al. 2006, USDA Forest Service 2008, Juday 2008).

30 **Freshwater Ecosystems:** While effects will vary regionally, impacts to Alaska's freshwater ecosystems are
31 generally expected to include reduced summer and fall stream flows, increased winter flooding, warmer
32 summer stream temperatures, loss of perched lakes and other surface water sources underlain by permafrost,
33 and potential water quality changes. Changes to freshwater species will occur, as species adapted to colder
34 conditions find it more difficult to thrive and species adapted to warmer water temperatures benefit (including
35 invasives). These impacts will have major effects on people who access and harvest the fish and wildlife that
36 depend on freshwater habitat, as well as entities seeking freshwater appropriations for community, industrial
37 or other purposes (ACIA 2004, White et al. 2007, Wrona et al. 2006).

¹ Climate change is expected to drive significant ecosystem changes in Alaska in the coming decades. The Natural Systems Technical Work Group (NS TWG) summarized changes to Alaska's ecosystems and expected future trends in www.climatechange.alaska.gov/aag/docs/AAG4a_NSTWG_DftOptnsCtlg_17dec08.pdf.

1 **Natural Systems Adaptation Strategy**

2 Climate change is already altering the natural ecosystem services that provide life requisites and cultural well-
 3 being in Alaska. **The Natural Resources Adaptation Strategy recommends actions that the State of**
 4 **Alaska should take to sustain the natural ecosystem services that meet society’s essential needs,**
 5 **through adaptation to changing environmental conditions.** To sustain ecosystems services, the State
 6 must adaptively manage its biotic natural resources – by managing negative impacts and capitalizing on new
 7 opportunities, in coordination with others who manage or benefit from these resources.

8 **The State of Alaska has an essential leadership role in adapting to natural systems change.** State
 9 government is a primary manager of Alaska’s natural biotic resources – with management authority and
 10 responsibility for fish and wildlife conservation and harvest, forest and wildland fire management, freshwater
 11 appropriations, Alaskan agriculture, infrastructure development, and use of State lands and other resources.
 12 The State must be fully prepared to adapt its management policies, strategies and actions to respond flexibly
 13 to the effects of climate change on natural ecosystem services and the human use of those services. The
 14 State’s planning and response actions must also be fully coordinated with the federal government, local
 15 communities, tribes, industry, Non-Governmental Organizations (NGOs), universities and the public.

16 The five adaptation options recommended for the NS sector are **targeted to sustaining the natural**
 17 **ecosystem services that meet Alaskan’s essential needs for food, water, renewable resource**
 18 **economies, community stability and safety, and cultural well-being.** Box 5-2 summarizes the NS

Box 5-2. Overview of Natural Systems Recommendations

NS-1 Fisheries Management

Incorporate climate change into fisheries management and assist fishing communities and users in adaptation.

NS-2 Wildland Fire

Review and modify Alaska’s wildland fire policy and programs.

NS-3 Freshwater Management

Address the effects of climate change on Alaska’s freshwater resources through adaptive management, supported by improved hydrologic data.

NS-4 Invasive and Eruptive Species

Reduce introduction and spread of invasive species and eruptive species in the context of climate change.

NS-5 Fish and Wildlife

Prepare for adaptive management of fish and wildlife.

19 recommendations.

20

21 These recommendations build on existing state authorities and programs, and will move Alaska forward
 22 substantially in its ability to adapt to climate change impacts. Implementation of these options will require
 23 leadership and policy direction, as well as a moderate investment in staffing and funding to complete priority

1 tasks. However, through this work, the State will take a major step forward in integrating adaptive
2 management to climate change over the long-term into the State's resource management programs and
3 practices, so that it becomes a way of doing business – not a suite of separate initiatives.

4 The NS sector encompasses a wide range of ecosystems, biotic resources and ecosystem services; yet there
5 are common approaches that will improve the State's capacity for adaptive management across this broad
6 spectrum. Recommended approaches include:

- 7 • Organize, coordinate and facilitate access to research and monitoring data, and identify important data
8 gaps (e.g., data essential to adaptive management of fish and wildlife conservation and harvest;
9 hydrologic data essential to freshwater resource management).
- 10 • Review and modify (as needed) resource management policies, practices and plans, to facilitate
11 adaptive management to address climate change impacts (e.g., fishery management plans; wildland fire
12 response practices; water management policies).
- 13 • Provide strategic plans and tools to accomplish specific, effective adaptive actions (e.g., regulation
14 change for adaptive management of wildlife harvest; strategic plans for invasive and eruptive species
15 control; plans for community wildfire protection and management of high-risk fire areas.)
- 16 • Establish and/or fully utilize effective forums for coordination and communication to combine and
17 leverage resources and increase effectiveness (e.g., Invasive Species Council, Alaska Water Resources
18 Board.)
- 19 • Increase the adaptive capacity of local communities, the public and others who benefit from ecosystems
20 services (e.g., provide information/technical assistance to fishing-reliant communities; prepare
21 community wildfire protection plans.)

22 These recommendations represent a concise set of feasible actions that the State of Alaska can lead and
23 accomplish, generally in the short- to mid-term, with modest additional funding. The recommendations
24 represent high priority actions, based on criteria that include significance of impacts addressed, anticipated
25 benefits, effectiveness, cost and feasibility of the adaptation action; timing considerations; and the adaptive
26 capacity of the natural ecosystem and human uses of the ecosystem. Research will be a critical part of these
27 recommendations, as described in Box 5-3. The recommendations are also intended to build on existing
28 public and private sector programs and activities as described in Box 5-4. Both these boxes appear at the
29 end of this chapter.

30 In addition to the recommendations presented in this chapter, there is a substantial need for coordination and
31 sharing of data regarding climate change and its effects in Alaska, and assurance that entities that need this
32 data to build their adaptive capacity (e.g., local communities, tribes) can access, understand and successfully
33 apply these data and findings. This recommendation is presented in Chapter 8, "Common Themes," as
34 Common Themes Option #1, establishment of an *Alaska Climate Change Knowledge Network*. *There is also*
35 *a need to increase climate change education in the Alaska school system, an option that is also presented in*
36 *Common Themes.*

37

38

Option	Option name	Type of option										Implementation			
		Coordination				Data collection (research, monitoring, observation, etc.)	Regulatory / programmatic change or addition	Assessment, evaluation, or planning	Capacity building, education, outreach	Direct or indirect financial assistance (e.g., tax incentives)	Capital improvements	Requires new /institutions / government agency	Requires new staffing	Requires funding	Requires new legislative authority
State interagency coordination	Community response and assistance	Data management	Access to data and "knowledge" sharing												
NS-1	Fisheries Management	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	possibly	✓
NS-2	Wildland Fire Management	✓	✓			✓		✓	✓				✓	✓	✓
NS-3	Freshwater Management	✓				✓	✓						✓	✓	✓
NS-4	Invasive and Eruptive Species Prevention & Response	✓				✓		✓					✓	✓	✓
NS-5	Adaptive Fish & Wildlife Management	✓	✓	✓	✓	✓	✓						✓	✓	✓

1

2 **Description of Natural Systems Recommendations**

3 This section describes the options recommended for the Natural Systems sector.

4 **NS-1 Incorporate Climate Change into Fisheries Management and Assist Fishing**
 5 **Communities and Users in Adaptation**

6 The State of Alaska will take into account climate change impacts when developing fisheries policy and
 7 management options for the state’s commercial, recreational, subsistence and personal use fisheries. In
 8 addition, because of its contribution to Alaska’s economy and jobs, the State will develop a program to assist
 9 the commercial fishing industry, and the communities and user groups reliant on the industry, in adapting to
 10 the impacts from climate change. These actions will improve the adaptive capacity of state managers, the
 11 fishing industry, and fishing-reliant communities to changes in fish species ranges, distribution and abundance
 12 – and address the sustainability and conservation of fisheries. Key elements of NS-1 include:

- 13 1 Review of the State’s fishing-related statutes, policies, management actions, and programs to
 14 determine if and how climate change considerations might be included in these. This review
 15 could be conducted by state agencies, or through a combined effort of agencies and a
 16 stakeholder group.

- 1 2 Comprehensive assessment of existing habitat, fish species and stock monitoring programs for
2 commercially-fished species to determine their effectiveness and how better information could
3 facilitate meaningful responses to climate change. A panel of agency scientists and independent
4 scientific experts would best accomplish this assessment. This assessment must go hand-in-
5 hand with development of a comprehensive long-term monitoring program that builds upon
6 existing federal and state programs, that addresses physical and biological components, fisheries
7 abundance and distribution, habitat monitoring, human activity and effects, and socioeconomic
8 data trends.
- 9 3 Development of a centralized source of information regarding effects of climate change on marine
10 and freshwater ecosystems and fisheries (see the *Alaska Climate Change Knowledge Network*,
11 proposed as Common Themes Option #1).
- 12 4 Development of a long-term strategy to work with fishing-reliant communities and businesses to
13 identify the needs for modified or new fisheries-related infrastructure to meet the changing needs
14 of the industry and fishermen, including possible construction, loans, etc.

15 Alaska's fisheries are an essential part of the state's economy, food supply, heritage and culture. The potential
16 negative impacts of *not* being prepared to adapt to changes in the state's fisheries cannot be overstated.

17 The State of Alaska could realistically implement these actions in the short- to mid-term with the leadership of
18 the Alaska Department of Fish and Game (ADF&G), in cooperation with federal fisheries managers, the
19 University, fishing-reliant communities, the fishing industry and other stakeholders. Legislative action would
20 be required only if changes to statutes were identified as required for adaptive management. Completing the
21 assessments and strategic planning described above would not be high cost. However, substantial funding
22 would be needed to implement a more robust marine ecosystem monitoring program (#2 above) or to fund
23 changes to fisheries-related infrastructure (#4). New federal funding sources would likely be required to
24 implement these initiatives (e.g., Ocean Trust Fund).

25 This recommendation is linked to several high priority research needs, including reviewing effective adaptive
26 management programs from other fishing-reliant countries and states, and developing a comprehensive long-
27 term monitoring program for marine ecosystem changes. As noted above, NS-1 is also linked to Common
28 Themes Option #1.

29 NS-2 Review and Modify Alaska's Wildland Fire Policies and Programs

30 The State of Alaska will thoroughly review and modify as appropriate, Alaska's wildland fire policy and
31 programs to address potential climate-induced increases in wildland fire frequency, size and geographic
32 location. Key elements of NS-2 include:

- 33 1 Increase the capacity of communities to initiate, complete and implement Community Wildlife
34 Protection Plans (CWPP) – providing additional emphasis and funding to a well-established state
35 program.
- 36 2 Review selected wildland fire management practices for lands in Alaska, including special
37 consideration of tundra wildfires, which have increased in the last two decades due to warming.

- 1 **3** Development of a comprehensive fuels management program to treat high-risk areas through fire
2 and mechanical fuel treatment, to minimize negative impacts of wildland fire on humans and to
3 increase beneficial aspects of fire, especially to wildlife habitat.

4 Taking these actions will benefit public health and safety (life and property), help maintain healthy forest
5 ecosystems, improve homeowner and community preparedness and capacity, provide jobs, supply woody
6 biomass for carbon neutral energy projects, and potentially reduce greenhouse gas (GHG) emissions from
7 wildland fires.

8 These recommendations build upon programs and coordinating bodies (state, federal, community, non-
9 government organization) that are already in place, with coordination by the Alaska Department of Natural
10 Resources (DNR), Division of Forestry. The actions are highly feasible, could be completed in the short-
11 mid-term and are not high in cost. Addition of a CWPP coordinator position and planning funds would be
12 needed to achieve the desired target of completing five new CWPPs each year for the next ten years and
13 keeping all plans updated. Additional funding may also be necessary if a decision were made to implement a
14 higher fire protection status in regions of the state. Federal funding is generally available to support fuels
15 management projects in high-risk areas.

16 **NS-3 Address Effects of Climate Change on Alaska's Freshwater Resources through**
17 **Adaptive Management, Supported by Improved Hydrologic Data**

18 The State of Alaska will improve the capacity of its freshwater management program to adapt to the impact of
19 climate change to meet the diverse needs for freshwater in Alaska. Key elements of NS-3 include:

- 20 **1** Advocate for and coordinate with the federal government and others to fill the substantial need for
21 additional, essential data on stream flow and groundwater hydrology.
- 22 **2** Reestablish the Alaska Water Resources Board to improve coordination among water resource
23 agencies and with the public.
- 24 **3** Protect water for fish and wildlife habitat through reservation of instream flows, in rivers and lakes
25 for which there is sufficient hydrologic data.
- 26 **4** Review and adjust water management laws, policies and practices, as necessary, to improve
27 adaptive capacity.

28 Natural ecosystems, communities, residents, industries, and transportation/utility systems all benefit from use
29 of Alaska's freshwater resources. By closing existing substantial data gaps and strengthening its water
30 management structure, the State will be better prepared to develop a strategic approach to water
31 management in the face of climate change, assess risk of water shortage and the need for replacement
32 sources within and between regions, avoid over-appropriation and protect beneficial uses. These actions
33 would be taken under the leadership of the DNR Division of Mining, Lands and Water and Department of
34 Environmental Conservation (DEC).

35 Alaska's primary water management challenge is the lack of sufficient surface and groundwater hydrologic
36 data. This option recommends a concerted effort to identify sources of data regarding the quantity and quality
37 of Alaska's freshwater sources, crucial data gaps, and a strategic plan for filling gaps. Very substantial
38 funding would be needed to provide sufficient data for hydrologic modeling and well-informed decisions on

1 water appropriation. Substantial federal funding sources would be needed and data collection would need to
2 be strategically prioritized to use funds to their greatest advantage.

3 Reestablishment and funding of the public/private Alaska Water Resources Board (the board is authorized,
4 but has not been seated since 1994) would provide needed Cabinet-level emphasis to water resource
5 management issues and programs, including coordination with DNR regarding improving data and the
6 potential need to adapt Alaska's water management laws, policies and practices, and the water rights
7 adjudication process. Additional state agency funding would be needed to achieve a desired target of
8 completing adjudication of water rights within five years for the fish-bearing streams in South, Central and
9 Interior Alaska that have adequate hydrologic information.

10 NS-4 Reduce Introduction and Spread of Invasive and Eruptive Species

11 The State of Alaska will expand its efforts to be an active partner with all levels of government and other
12 entities in addressing the problem of invasive and eruptive species in Alaska. NS-4 recommends state
13 support for the Legislature's establishment of the Alaska Invasive Species Council (House Bill 12), and State
14 commitment to partnering with others to prevent and control invasive and eruptive species in Alaska.

15 The combination of changing climate (lengthening growing seasons and warming temperatures) and
16 increasing globalization has dramatically increased the rate of introduction and the spread of non-native,
17 invasive species in Alaska. Invasive plants, eruptive insects and diseases, and invasive marine species have
18 the potential to damage important economic sectors such as fisheries and forestry, as well as to alter fire
19 cycles and subsistence opportunities and to spread disease.

20 NS-4 recommends that the State of Alaska immediately join in the work underway to address invasive species
21 in Alaska.² ADF&G, DNR, DEC and Department of Transportation and Public Facilities (DOT&PF) need to be
22 fully involved. Establishment of the Alaska Invasive Species Council would cement the partnership between
23 the state and other levels of government, and would provide leadership, policy decisions, and leverage and
24 coordination of resources and authorities to implement effective prevention and response actions.

25 Many actions to prevent introduction and to control invasives already in Alaska could be implemented within
26 the short- to mid-term (two to five years). Funding for two state positions (ADOT&PF vegetation management
27 and DNR plant/wood products inspector) is recommended to address two significant points where invasives
28 can be effectively controlled. It is *much more cost-effective to invest in prevention and early control of*
29 *invasive and eruptive species*, than to combat their spread and their substantial impacts to Alaska's
30 ecosystems and economy in the future

31 NS-5 Provide for Adaptive Management of Fish and Wildlife

32 The State of Alaska will improve its capability to adaptively manage fish and wildlife species in Alaska to
33 assure sustainable management of these important resources under conditions of rapid and substantial
34 climatic change. NS-5 proposes two specific actions under the leadership of ADF&G:

² This recommendation would contribute to and build on work underway by the ad hoc statewide Alaska Committee on Noxious and Invasive Plant Management (CNIPM) and the Alaska Invasive Species Working Group (AISWG).

- 1 1 Develop and adopt a more timely regulatory process for the harvest of wildlife to adapt and
2 respond to short- and long-term changes in climate that can decrease harvest success under a
3 static harvest season.
- 4 2 Develop a coordinated framework that documents existing fish and wildlife monitoring efforts (for
5 both harvested and non-harvested species), identifies priorities for monitoring in the context of
6 climate change, and identifies gaps and potential for collaboration. This option would also include
7 development and use of a common structure for cataloguing and disseminating monitoring
8 information, such as the *Alaska Climate Change Knowledge Network*, proposed as Common
9 Themes Option #1.

10 Under sub-option #1 above, the Alaska Board of Game would need to delegate regulatory authority to state
11 wildlife managers to adjust wildlife harvest regulations in-season when situations presented by climate change
12 hinder harvest or meat care (e.g., warm, dry conditions reduce access by boat and/or change migration
13 routes). This action could be implemented in the short-term at low cost as a pilot study in a community or
14 small region. A working group could develop a proposal to the Board of Game for an inseason management
15 option, to determine if it is a management tool that will help respond to climate change impacts on hunting
16 success and to meet subsistence needs for wildlife. (This recommendation focuses on management of
17 wildlife harvest; note that state fisheries management regulations and practices already provides for adaptive
18 in-season management by state fishery managers.)

19 Under sub-option #2 above, collaboration amongst agencies, scientists and stakeholders to develop a
20 monitoring framework for fish and wildlife species in Alaska could be accomplished in the short- to mid-term;
21 the cost of this initial product (framework, data coverage, data gaps) is not expected to be high. However,
22 implementation of additional monitoring to fill data gaps would require substantial funding. This
23 recommendation is linked to NS-1, which recommends a similar assessment for monitoring focused on
24 commercially fished species and the habitats that support those species. As noted above, it is also linked to
25 Common Themes Option #1, which addresses coordinated access to data and information regarding climate
26 change.

27 **[Important note: Options NS-6, Support and Expand Sustainable Agriculture, and NS-7, Promotion of**
28 **Climate Change Literacy, were removed from the Natural Systems recommendations. NS-6 was to support**
29 **and expand sustainable agriculture production and marketing in Alaska, recognizing the importance of local**
30 **agriculture to Alaska's food security and to develop an Alaska food policy and strategic plan to increase**
31 **reliance on locally produced agricultural products was retracted by the AAG due to the fact that it was not a**
32 **need resulting from climate change. NS 7, to Develop curriculum and training to support climate change**
33 **education in grades K-12 was moved to Common Themes.]**

Box 5-3. Natural Systems Recommended Research Needs

The Research Needs Work Group identified several needs both to assist implementing the recommendations and to help the State of Alaska better understand the impacts of climate change on its natural systems:

OVERARCHING RESEARCH NEEDS

- NS/RN- 1 Develop better hydrology data and models statewide.
- NS/RN- 2 Identify permafrost thaw hazards and incorporate into engineering guidelines.
- NS/RN- 3 Identify and research laws, policies, and regulations that could be modified to better support adaptation.
- NS/RN- 4 Implement local climate change scenario planning workshops in communities across Alaska (coastal, arctic, interior, etc.).
- NS/RN-5 Identify and assess health and safety hazards resulting from climate change
- NS/RN-6 Coordinate data integration.
- NS/RN-7 Fill gaps in geospatial data coverage, aerial photography, digital elevation models (DEM), and remote sensing data that are needed to assess and forecast climate change impacts.
- NS/RN-8 Conduct coastal mapping and shoreline characterization.
- NS/RN-9 Assess, model, and monitor coastal impacts of changes to sea level and ice.
- NS/RN- 10 Develop and refine down-scaled climate models.
- NS/RN-11 Coordinate climate and ecosystem monitoring programs among agencies, organizations, and institutions.
- NS/RN-12 Work with communities to determine appropriate indicators of climate change and community impacts. Improve monitoring of key climate change indicators & effects, with emphasis on effects having large societal impacts. Monitor climate change indicators and their societal impacts.
- NS/RN-13 Conduct research on protecting community water supplies and instream flows.
- NS/RN-14 Expand research and monitoring of contaminants deposition and bioavailability under changing climate.
- NS/RN-15 Acquire or produce vegetation maps that are usually compiled from satellite imagery. Ortho rectified imagery would show human improvements and vegetation. A base map is needed for the state.
- NS/RN-16 Assess communications strategies for climate change information.

Continued in next box...

Box 5-3. Natural Systems Recommended Research Needs (continued)***SPECIFIC RESEARCH NEEDS*****FISHERIES**

NS/RN-17 Synthesize current information about climate change impacts on fisheries and assess its reliability and degree of uncertainty.

NS/RN-18 Conduct Arctic Ocean fisheries assessments.

NS/RN-19 Increase real-time monitoring and forecasts of physical ocean conditions (winds, waves, sea ice, currents, temperature, salinity, pH, etc.).

NS/RN-20 Research fisheries policy considerations.

NS/RN-21 Conduct physical, biological, and socioeconomic monitoring consistently over time to understand environmental change, distribution and abundance of freshwater, marine and anadromous species, and societal impacts.

NS/RN-22 Consider need for protected fish conservation areas.

WILDLAND FIRE

NS/RN-23 Expand modeling of wildland fire, fuel, and smoke.

NS/RN-24 Review and coordinate wildland fire policies with Canadian counterparts.

NS/RN-25 Research Tundra fire effects and develop measures to reduce impacts.

NS/RN-33 Research and monitor forest response after disturbance. (retained although Forestry & Wood Biomass was moved to the Mitigation Advisory Group)

INVASIVE SPECIES

NS/RN-26 Identify and develop methods to assess and control invasive and irruptive plant, animal, and diseases that are likely to become established, expand their range, or be intentionally introduced in Alaska due to climate change.

NS/RN-27 Provide effective monitoring, forecasting and response to marine invasive species.

FISH AND WILDLIFE

NS/RN-28 Improve wildlife and fisheries populations and harvest rate data and access.

NS/RN-29 Develop projections of future changes to potential wildlife habitat that are likely to result from climate-driven changes to landscape, landcover (vegetation), wildfire frequency and intensity, permafrost thaw/thermokarst, and fragmented migratory corridors.

NS/RN-30 Evaluate and improve methods for caribou population enumeration.

NS/RN-31 Assess disjuncts between calendar dates for legal harvest, and actual biological behavior of species.

NS/RN-32 Identify how "sentinel" ecosystems are changing.

SUSTAINABLE AGRICULTURE

NS/RN-34 Research agricultural products and practices suitable for changing conditions. [Retained although this option has been retracted. 07/30/09]

NATURAL HAZARDS

NS/RN-35 Assess effects of climate on safe access for hunting, fishing and other subsistence activities.

Update the Environmental Atlas of Alaska and Alaska Engineering Design Information System (AEDIS).

For additional information on each recommendation, see Research Needs Work Group (2009).

1

Box 5-4. Relevant Current Activities

There are many ongoing research and management programs that are relevant to the effects of climate change on Alaska's natural systems and ecosystem services. The most effective adaptation actions by the State of Alaska will be those that partner with, contribute to, leverage, and build upon these types of existing efforts. Examples of relevant current activities include:

NS-1 Fisheries and NS-5 Adaptive Management of Fish and Wildlife

There are many government agencies, universities and non-government organizations involved in monitoring the status of Alaska's fish and wildlife, their habitats and the effects of climate change on these important resources.

NS-2 Wildland Fire

The existing Alaska Wildland Fire Coordinating Group is a highly-effective interagency mechanism for adaptive management of fire response and management. The Community Wildfire Protection Plan program is an existing, but not well-funded program. State, federal and University mapping projects provide essential baseline information (e.g., vegetative land cover).

NS-3 Freshwater Management

Relevant programs include the State's existing management authorities for water quantity and quality; hydrologic data collection by federal agencies, the University of Alaska, private sector and others; and ad hoc, occasional coordination regarding water management and hydrologic issues at the agency staff level (e.g., Interagency Hydrology Committee for Alaska).

NS-4 Invasive and Eruptive Species

Several federal agencies have recently developed effective invasive species programs in Alaska. Ad hoc agency groups have been operating (Alaska Committee for Noxious and Invasive Plant Management, Alaska Invasive Species Working Group), but are hampered by lack of consistent State participation.

2