

# **Research Needs Work Group**

## **Recommendations on Research Needs Necessary to Implement an Alaska Climate Change Strategy**

Submitted to the Alaska Climate Change Sub-Cabinet

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# 1 Executive Summary

## The Challenge

Native and long-time Alaskan residents describe dramatic changes in Alaska's climate and the chronic and catastrophic effects these changes are having on their lifestyles and cultures. Knowledgeable scientists, engineers, leaders, and decision-makers acknowledge that climatic changes are occurring in Alaska and have great potential, in consort with other factors, to adversely impact the natural, social, economic, and infrastructure systems that Alaskans rely upon for their way of life. Nearly everyone, however, unanimously laments the paucity of data, analyses, information infrastructure, and decision-support and sharing tools necessary for effective assessment and response to such changes.

While many of the impacts are potentially negative, others may be beneficial. For example, reduced Arctic sea ice may open new shipping opportunities. A warming climate may increase growing seasons, thereby increasing agricultural opportunities. New fishing opportunities may become available in the Arctic. Each of these will require assessment and monitoring.

There is no single agency, organization, or collaborative association within Alaska that is tasked with systematically coordinating the identification, collection, compilation, analysis, and publishing of climate change data and research. This important task is required to ensure the quality necessary to effectively support decision-making and evaluate and manage multifaceted risks and threats such as those associated with climate change in Alaska. However, there are many scientific agencies and organizations collecting and interpreting natural and economic data in Alaska that can be used in an overall climate change response strategy. The challenge is to coordinate the many different data sets, identify the information and data gaps for climate related policy and mitigation/adaptation efforts, and make sure sufficient funding is available and distributed to do the work.

## One Process

Through Administrative Order 238 Governor Sarah Palin established, a Sub-cabinet on Climate Change to advise her on the preparation and implementation of an Alaska climate change strategy. The Sub-cabinet established four advisory groups. The four groups included the:

- Immediate Action Working Group (IAWG) focusing on near term actions needed in Alaska;
- Mitigation Advisory Group (MAG) to identify and propose measures to mitigate Alaska’s greenhouse gas emissions;
- Adaptation Advisory Group (AAG) to identify and propose methods to adapt to the impacts of climate change on Alaska; and
- Research Needs Work Group (RNWG) to recommend research strategies for mitigating greenhouse gases and adapting to the impacts of climate change.

The RNWG was established to assist the Sub-cabinet in identifying needed research to implement mitigation and adaptation strategies identified by the Advisory Groups, and ultimately, the Sub-cabinet. Research needs were broadly defined and included measures to implement or encourage:

- data collection and management;
- monitoring;
- addressing workforce needs;
- scientific research;
- the development of engineering standards, practices and other support tools;
- infrastructure needs and improvements;
- technology development;
- the assembly of traditional knowledge; and,
- modeling.

To develop its recommendations, the RNWG worked with the Technical Working Groups (TWG) of the MAG and AAG to identify research needs that dovetail with the policy recommendations being offered for the climate change strategy. Input was compiled from the policy recommendations from the MAG TWG:

- Cross Cutting (7)
- Energy Supply and Demand (9 recommendations)
- Forestry, Agriculture and Waste Management (3 recommendations)
- Oil and Gas (8 recommendations)
- Transportation and Land Use (10 recommendations)

and from the AAG TWG:

- Economic Activities (5 recommendations)
- Health and Culture (5 recommendations)
- Natural Systems (7 recommendations)

- Public Infrastructure (3 recommendations)

Additional policy recommendations made by the RNWG are also presented in the respective sections.

## The Vision

The Research Needs Work Group (RNWG) envisions an integrated research and knowledge management infrastructure supporting multi-disciplinary systematic analyses and decision-making as an integral part of the climate change strategy that will allow Alaska to effectively, economically, and sustainably adapt to and mitigate the consequences of climate change.

## The Strategy

The RNWG members recognized that addressing the impacts to Alaska from climate change and the value of efforts to mitigate greenhouse gases will be most effective through a systematic approach. The State of Alaska should pursue this systematic approach by:

- Developing a comprehensive inventory of ecosystems, communities, resources and infrastructure vulnerable to climate change;
- Developing and implementing a robust monitoring system of key climate change indicators;
- Increasing the current acceptance of risk by managing uncertainty with strengthened science-based research and probabilistic scenario analyses;
- Embracing a systematic outcome-focused approach to decision-making that addresses sustainability, economic impact, climate change adaptation needs, and long-range planning;
- Promoting innovation and continuous quality improvement by increasing applied research capacity and incentives for new methods for adapting to impacts and managing mitigation measures; and
- Establishing mechanisms to ensure communication and coordination among State agencies and with federal agencies and with stakeholders to provide research-derived information to address multi-jurisdictional needs in mitigating greenhouse gas emissions and adapting to climate change.

The RNWG encourages the leaders of the Executive Branch, the Legislature, and the University to assume a more proactive and collaborative role in planning, developing, and clarifying a strategic vision, goals, and performance measures for State government in promoting sustainable communities and addressing climate change in Alaska. The strength and effectiveness of this integrated strategic planning will be a function of the specificity of the state's roles, focus on long-term sustainability, and extent of collaboration with stakeholders. The RNWG believes that this strategic planning is necessary for, and will be the most effective way to prioritize the research needs identified herein.

## Identified Research Needs

This report identifies both overarching and specific research needs that are necessary to implement policy recommendations being offered by the MAG and AAG TWGs. Included is an evaluation of the completeness of the TWG policy recommendations and the identified research needs necessary to implement the identified recommendations. An assessment of the research required to fully complete the goals of specific suggested policies is included. For each identified needs, a description of the need is provided. In total, 52 overarching and 95 specific research needs are identified.

## The Urgency

Impacts to Alaska from climate change have been increasingly recognized over the past decade, with the breadth of impacts well documented since 2004 (ACIA, 2004). Research strategies have been evolving to address the challenges being faced in Alaska. These include advanced models, various climate change scenarios, and research programs aimed at understanding the rate of change and potential risks to state resources. There is a general consensus that a systematic approach within a multi-disciplinary research strategy will provide the best science-based decision making tools for proactive solutions. It takes time, however, to transform research data to useful information. Identifying research today, with particular attention to the cross cutting needs, will support better decisions in a shorter time frame and ensure that Alaska leads the nation in successfully adapting to the impacts of climate change, while mitigating the greenhouse gas emissions as part of our national role.



## 2 Introduction

The Arctic is a unique and dynamic ecosystem. Many natural and anthropogenic factors influence this system. Of these, a changing climate has become a dominant driver of change in the Arctic. Native and long-time Alaskan residents describe dramatic changes in Alaska's climate and the chronic and catastrophic effects these changes are having on their lifestyles and cultures. Knowledgeable scientists, engineers, leaders, and decision-makers acknowledge that climatic changes are occurring in Alaska and have great potential, in consort with other factors, to adversely impact the natural, social, economic, and infrastructure systems that Alaskans rely upon for their way of life. While many of the impacts are potentially negative, others are potentially beneficial. For example, reduced Arctic sea ice may open new shipping opportunities. A warming climate may increase growing seasons, thereby increasing agricultural opportunities. New fishing opportunities may become available in the Arctic.

Nearly everyone unanimously laments the paucity of data, analyses, information infrastructure, and decision-support and sharing tools. This leads to significant uncertainty in our ability to predict the effects of climate change and to develop responses to such changes. Despite this, there is an urgent need to develop proactive mitigation and adaptation strategies to climate change.

There is no single agency, organization, or collaborative association within Alaska that is tasked with systematically coordinating the identification, collection, compilation, analysis, and publishing of climate change data and research. This important task is required to ensure the quality necessary to effectively support decision-making and evaluate and manage multifaceted risks and threats such as those associated with climate change in Alaska. However, there are many scientific agencies and organizations collecting and interpreting natural and economic data in Alaska that can be used in an overall climate change response strategy. The challenge is to coordinate the many different data sets, identify the information and data gaps for climate related policy and mitigation/adaptation efforts, and make sure sufficient funding is available and distributed to do the work.

There is a general consensus that a systematic approach within a multi-disciplinary research strategy will provide the best science-based decision making tools for proactive solutions. It takes time, however, to transform research data to useful information. Identifying research today, with particular attention to the cross cutting needs, will support better decisions in a shorter time frame and ensure that Alaska leads the nation in successfully adapting to the

impacts of climate change, while mitigating the greenhouse gas emissions as part of our national role.

It is in this frame that Governor Sarah Palin issued Administrative Order 238. This order established a Sub-cabinet on Climate Change to advise her on the preparation and implementation of an Alaska climate change strategy. The Sub-cabinet established four advisory groups. The four groups included the:

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To develop its recommendations, the RNWG worked with the Technical Working Groups (TWG) of the MAG and AAG to identify research needs that dovetail with the policy recommendations being offered for the climate change strategy. Input was compiled from the policy recommendations from the MAG TWG:

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### 3 Overarching Needs Summary

The overarching needs identified by the RNWG are:

- **Improved downscaled (local) climate models:** The ability to effectively implement policy recommendations is largely dependent upon being able to act at local levels. This necessitates being able to predict the impacts of a changing climate locally. Programs like Scenario Network for Alaska Planning need to be expanded to include more variables and greater specificity, as well as the variety of Alaska ecosystems (ocean, coastal, terrestrial) and the needs of natural system services (e.g. wildlife, fisheries, subsistence, economic, etc.).
- **Need for baseline environmental research and monitoring:** The success and accuracy of downscaled models is largely dependent upon the quantity and quality of data available. There is an urgent need to collect baseline environmental research and monitoring data. This includes developing a robust baseline monitoring program of a variety of physical, chemical, biological and socio-economic variables that take into account seasonal, annual, and decade-long variability. It also includes implementing a well-developed research program that includes process studies and applications.
- **Improved research infrastructure:** Our ability to collect data is largely dependent upon our ability to improve our research infrastructure (e.g. computers, radars, ships, satellites, personnel, etc). This includes research as well as baseline data collection and monitoring.
- **Improved data integration and sharing:** To assure there is not duplication of efforts it is imperative to coordinate data integration and sharing between agencies. This will ensure the success of various inter-disciplinary efforts that will be needed to address climate change issues. Other key elements include data management, interoperability, access and archiving.
- **Multiple level decision-making tools:** Many of the identified policy recommendations will need to be implemented at the local level. There is an urgent need for expanding the availability of appropriate decision-making tools for local and state officials.
- **Adaptable legal and policy frameworks:** Many laws, regulations and policies on the federal, state, and local levels were developed for a static environment where climate change was not recognized. The challenge for government leaders and businesses will be to adapt to a future made less certain due to a more rapidly changing climate. This will necessitate an evaluation of existing laws, regulations and policies and possible changes to institutional, legal and policy frameworks in an adaptive manner
- **Improved baseline mapping:** The ability to predict landscape level changes due to climate change is dependent upon being able to define the status quo. Unfortunately,

few baseline maps of key environmental variables are available for Alaska. Improved baseline mapping and associated data collection is a critical need.

- **Education and Outreach:** Our ability to implement policy changes is largely affected by public perception and understanding. There is a critical need to develop and implement an education and outreach program aimed at improving public understanding of climate change and its affects, as well as the need to address them.

# 4 Recommendations: Mitigation

## Mitigation Technical Workgroups

The Mitigation Advisory Group (MAG) was tasked with identifying policy recommendations that could be implemented to reduce Alaska GHG emissions and carbon footprint. Five technical workgroups (TWGs) were formed as a part of the MAG:

- Cross Cutting
- Energy Supply and Demand
- Forestry, Agriculture and Waste Management
- Oil and Gas
- Transportation and Land Use

### 4.1 Cross Cutting (CC) TWG

#### **TWG Recommendations**

- CC-1. Establish an Alaska Greenhouse Gas Emission Reporting Program
- CC-2. Establish Goals for Statewide GHG Emission Reduction
- CC-3. Identify and Implement State Government Mitigation Actions
- CC-4. Integrate Alaska's Climate Change Mitigation Strategy with the Alaska Energy Plan
- CC-5. Explore Various Market-Based Systems to Manage GHG Emissions
- CC-6. Create an Alaska Climate Change Program that Coordinates State Efforts for Addressing Climate Change

#### **RNWG Recommendations**

- CC-7. Assess the long-term economic impact of GHG emissions reporting and reduction programs on the Alaskan economy at statewide and local levels.

### Specific Research Needs

The RNWG did not identify specific research needs for this TWG. It is the opinion of the RNWG that research needs identified for other TWGs, in combination, will be sufficient to implement the identified policy recommendations.

## 4.2 Energy Supply and Demand (ESD) TWG

The Energy Supply and Demand (ESD) TWG was charged with evaluating climate change mitigation policy options related to energy. The ESD TWG prepared a suite of draft policy options, some of which contained elements of research and development, and one of which was specifically about research and development (see TWG Recommendations). As such, three of the policy options, ESD 7, 8 and 9 were lumped into one and it was from there forward referred to as the R&D policy option. A subgroup of TWG members generated the R&D Policy Option. In addition, a second subgroup was assembled to discuss the specifics about energy research that related to minimizing or managing carbon. These were then detailed and are included as research needs under unique identifiers.

The TWG did two things. First, it created a policy option for research (ES&D 7, 8 and 9). Only one “Policy Option” was drawn up for ESD 7, 8 and 9 and it is hereafter referred to as a single, group option. Second, a subcommittee generated a list of specific research needs on behalf of the TWG. The list of specific research needs was generated to address needs for the ESD policy options 1-6.

The R&D Policy Option (ESD 7,8,9) was directed to establishing programmatic incentives for participation and support of public and private investment in fundamental research, demonstration, and deployment of carbon-emission reduction and energy production technologies that hold promise for implementation throughout Alaska.

- Advanced technologies in electric power generation, both small-scale and large-scale, in fossil generation, nuclear generation, and renewables will provide greater efficiency in power supply for utility and industrial purposes.
- A statewide emphasis on enhanced utilization of new and emerging technologies that provide the end-use benefits of electric energy with greater efficiency will provide economic and environmental benefits throughout Alaska.
- The policy will provide incentives and reduce barriers to implementation of advanced generation technologies using the variety of energy sources available to Alaska.
- While emphasis may be provided on cold-climate applicability (e.g., combined heat and power) or other regional characteristics (e.g., geothermal availability) the emphasis will be on cost-effective supply and net environmental impacts.
- In addition to R&D on reducing CO<sub>2</sub> production, policy should encourage R&D on carbon capture and management. Such examples could include food production in greenhouses or other novel value-added carbon capture as well sequestration.

### **TWG Recommendations**

- ESD-1. Transmission System Optimization and Expansion
- ESD-2. Energy Efficiency for Residential and Commercial Customers
- ESD-3. Implementation of Renewable Energy
- ESD-4. Building Standards/Incentives
- ESD-5. Efficiency Improvements for Generators

- ESD-6. Energy Efficiency for Industrial Installations
- ESD-7. Implementation of Small-Scale Nuclear Power
- ESD-8. Research and Development for Cold-Climate Renewable Technologies
- ESD-9. Implementation of Advanced Supply-Side Technologies

#### **RNWG Recommendations**

No additional recommendations.

### **Specific Research Needs**

The list of specific research needs centered around two themes: managing carbon, and minimizing carbon. Both of these themes were limited to the aspects related to energy supply and demand.

#### **4.2.1 Carbon Capture, Sequestration and Management**

##### **4.2.1.1 Carbon sequestration research is needed to better understand the state's options for storing carbon in geologic formations. This research involves field investigation of likely sites. (Responds to Policy Option ES&D 7-9)**

Alaska has a major coal resource. New coal power plants or coal to liquids processes will likely either require carbon sequestration or be negatively impacted by carbon caps or taxes. To prepare the state for both managing the carbon dioxide it produces currently and for permitting of new carbon dioxide producing facilities, sequestration options must be available. **Action Type: Modeling, Data Management, Monitoring. Cross-Cutting Topics: Oil and Gas**

##### **4.2.1.2 Research is needed on value added carbon capture technologies such as carbon capture and use in greenhouses for food and energy production, carbon incorporation into high-tech products, such as carbon fiber or H<sub>2</sub> storage, enhanced oil recovery, and carbon addition to H<sub>2</sub> for fuels production. Many other options may also be available. Research is needed to determine which opportunities hold the greatest promise for Alaska. (Responds to Policy Option ES&D 7-9)**

To comply with future carbon caps, trading, taxation, and carbon dioxide reduction for mitigation purposes, the state needs to identify options for carbon dioxide management. Beneficial use makes the most sense if reasonable options are available. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: Oil and Gas**

- 4.2.1.3 Research is needed to improve generation efficiency from improved control and operation practices of existing generation capacity (e.g., diesel). This includes the management of hybrid systems which typically are very complicated from a management and control standpoint. (Responds to Policy Option ES&D 5,6)**

Carbon emissions can be reduced by increasing the efficiency of carbon producing processes such as diesel power generation and hybrid power systems. The goal is not to improve the efficiency of the diesel engine itself, but to introduce control strategies that would reduce the net carbon emissions from the diesel power plant without a reduction in supply. *Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: NA*

- 4.2.1.4 Research is need on the best application and best management of a coal-to-liquids technology as well as carbon capture and beneficial use. (Responds to Policy Option ES&D 7-9)**

Research on the use of coal in Alaska is needed to most effectively develop an abundant energy rich resource while achieving goals for mitigating climate change. *Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: NA*

## **4.2.2 Geothermal Research**

- 4.2.2.1 A site-specific geothermal resource assessment is needed. In addition, research and testing of low temperature power generation designs for power and heat, mineral recovery from geothermal brines, and ground source heat pumps is needed. Additionally, research into uses for power at or close to geothermal prospects should be conducted. Such uses could include value added mineral refining, timber processing, or greenhouse food/energy production. (Responds to Policy Option ES&D 3, 7-9. This potentially could be coupled with the Natural Systems, Policy Option 2B.)**

A general understanding of the state's geothermal potential is available. However, little site-specific information is available to assess feasibility of implementation. Without this information there is little chance that developers will be willing to invest in a geothermal prospect. Exploration often accounts for ¼ to ½ of the cost of a geothermal power development project. *Action Type: Modeling, Products, Monitoring. Cross-Cutting Topics: NA*

## **4.2.3 Hydropower and Hydrokinetic Research**

- 4.2.3.1 To make hydropower an effective and efficient power alternative, research is needed into technologies for fuel switching (e.g., from gas to electric heat), pumped storage and integration, reducing adverse intake icing conditions, and integration schemes for incorporating small-scale**



**hydro power in village settings where other generating technologies are being used. (Responds to Policy Option ES&D 3, 7-9)**

Hydropower has many different forms and has many issues that determine its ultimate effectiveness as a source of power. In this need hydropower is limited to water retention and passage through power generating turbines. In-river, tidal, and wave power is discussed in a subsequent need referred to as hydrokinetic power.

Research is needed on propeller and crossflow turbine runners to reduce manufacturing costs and advanced materials such as composite blades and other blade types not requiring extensive metal casting, and use of heat recovery for heat load dumps used to regulate hydropower frequency fluctuation. Testing is needed on intake screens for cold weather hydro applications, and water conservation schemes for preservation of reservoir storage during frequency regulation. To reduce the cost of hydropower programs, standardized plans for small hydro applications are needed with details on intakes, powerhouse, induction plants, tailraces, etc., Alaska needs friendly fish passage designs for in and out of a lake/reservoir, as well as research into how best to provide for flushing flows and sediments to replenish spawning gravels in fish streams, optimal winter instream flow releases for traditional hydropower projects, and improved methods to predict snow-melt and runoff for modeling reservoir operations. *Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: NA*

- 4.2.3.2 There is a need for hydrokinetic resource assessment, including a baseline inventory of possible development sites. Research is needed on the impacts of hydro on fish populations, hydrokinetic device testing, and optimization of hydrokinetic devices for the Alaskan environment (issues such as deployment, anchoring, ice effects, tidal energy capture, etc). Another area of research needed is the application of high pressure water in non-electrical generating applications such as mechanical grinding and processing. (Responds to Policy Option ES&D 3, 7-9)**

Many of Alaska communities are on rivers or along coastlines where hydrokinetic devices could augment power provided by diesel or another source. Unfortunately without some research into the likelihood of success and environmental impact of hydrokinetic devices, very little funding will be dedicated to such prospects. *Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: NA*

## **4.2.4 Wind Energy Research**

- 4.2.4.1 There remain significant issues with wind field modeling, grid integration, power storage, foundations, and de/anti-icing options for wind turbine**

**blades in Alaska that require additional research. (Responds to Policy Option ES&D 3, 7-9)**

Wind systems are being installed around Alaska. While they are producing power, many are not reducing the use of diesel as much as they could. This is largely a controls, grid integration, and power storage issue. The issue of foundations and de-icing are practical problems that increase the cost of wind projects. These issues could be resolved with some applied research and development. Other issues relate to wind field modeling. Wind field models can provide information about variability in power production and are needed before a windfarm can be adequately sited. *Action Type: Modeling, Products, Education/Outreach, Monitoring. Cross-Cutting Topics: NA*

#### **4.2.5 Biomass Technologies**

**4.2.5.1 Research is needed to find suitable biomass technologies for generating power in the smaller communities that could simultaneously provide space heating. (Responds to Policy Option ES&D 3, 7-9. This option could also overlap with options in the Forestry and Agricultural Waste Management technical working group.)**

Biomass produced heat could be coupled with greenhouse production of food and energy crops. Algae, for example, could be grown in concentrated masses in greenhouses and converted to biofuels. Heat, light and CO<sub>2</sub> from biomass burning could fuel the greenhouse operation. Little has been done in this area to prove the economics or other benefits of such an operation thereby limiting investment. A field-scale demonstration site would encourage the development of biomass generated heat and power (incl. food and energy) in Alaska.

There is also a need to optimize biomass development opportunities for rural heat and power as well as investigating the opportunities to cultivate biomass. For example, if willows can be cultivated and harvested for use in heat and power generation, the land area required for biomass production would be significantly reduced compared to harvesting of native biomass stands. *Action Type: Products, Data Management, Monitoring. Cross-Cutting Topics: NA*

#### **4.2.6 Nuclear Technologies**

**4.2.6.1 There are currently no commercial nuclear power plants operating in Alaska. As part of a diversified energy portfolio, nuclear power should be investigated. (Responds to Policy Option ES&D 7-9)**

There is a need to better understand the technologies and opportunities for nuclear power in Alaska. Potential matches between technologies and potential sites needs to be identified and studied. *Action Type: Products, Data Management, Monitoring. Cross-Cutting Topics: NA*

## 4.2.7 Transmission Technologies

**4.2.7.1 The Denali Commission has just finished a study into transmission potential for the state of Alaska. In particular, the potential for hub and spoke solutions to rural transmission were evaluated further. Research is needed into the vulnerabilities and efficiencies of small rural grids.** In particular, as many rural communities invest in renewable technologies, small grids could be looking at very high renewable penetration rates. The stability and efficiency of these grids is not known. Applied research and monitoring for high renewable penetration grids could develop new control strategies that would make these grids more stable and able to meet customer needs. **(Responds to Policy Option ES&D 1) Action Type: Products, Data Management, Monitoring. Cross-Cutting Topics: NA**

**4.2.7.2 Assess Advanced Coal Technologies and their applicability in Alaska. (Responds to Policy Option ES&D 7-9)**

Alaska has a major coal resource. New coal power plants or coal to liquids processes advances into clean coal processing or technologies such as in situ or on-site gasification. Much is unknown about clean coal technologies with respect to Alaskan Coal. In most cases, pilot studies for new technologies should be conducted. A testbed for clean coal technologies would help ensure success when technologies are finally implemented. *Action Type: Modeling, Data Management, Monitoring.*

## 4.3 Forestry, Agriculture and Waste Management (FAW) TWG

The Forestry, Agriculture and Waste Management (FAW) TWG reviewed and evaluated a number of policy options and narrowed the focus to three recommendations. The group did consider several ideas for agricultural projects, but the scope and scale of agriculture is fairly small in the state and thus the impact from a CO2 mitigation standpoint was low. The group focused their attention on the Forestry and Waste Management opportunities.

### **TWG Recommendations**

The TWG forwarded the following mitigation policy options for further consideration by the Mitigation Advisory Group (MAG) and the Climate Change Sub-Cabinet:

- FAW-1. Forest Management Strategies for Carbon Sequestration
- FAW-2. Expanded Use of Biomass Feedstocks for Energy Production
- FAW-3. Advanced Waste Reduction and Recycling

### **RNWG Recommendations**

No additional recommendations.

## Research Needs

### 4.3.1 Overarching Research Needs

#### 4.3.1.1 **Develop a protocol for determining carbon baselines, carbon sequestration rates, additionality permanence and leakage of carbon for silvicultural treatments in boreal and coastal forests.**

Carbon trading under a cap and trade system requires verification of carbon additionality above a baseline reference. This “additional” carbon can be sold as part of a mitigation strategy for a carbon producer that needs to exceed their cap. Silvicultural treatments need rigorous third party review to ensure they meet the needs of the market. *Action Type: Modeling, Data Management, Monitoring. Cross-Cutting Topics: Overarching, Natural Systems.*

#### 4.3.1.2 **Refine global climate models for better understanding of regional variations within Alaska. Provide means to disseminate these data.**

Improved monitoring and modeling data will allow for development and dissemination of environmental information and design criteria for use in adapting to climate change. *Action Type: Modeling, Products. Cross-Cutting Topics: Overarching.*

#### 4.3.1.3 **Study expected carbon losses during permafrost melt and addition of emissions to the Alaska GHG Inventory and Forecast (I&F).**

Better understanding of the GHG impacts of melting permafrost and appropriate representation in Alaska's GHG Inventory and Firecast There is a potential for large impact to the Inventory and Forecast report if these areas are considered to be anthropogenic. *Action Type: Modeling. Cross-Cutting Topics: Overarching*

#### 4.3.1.4 **Review IPCC materials on the definition of managed or unmanaged forests. Confer with in-state forestry experts to assess the proper classification of the Boreal Forest based on past and future management.**

There is a potential for a large impact on the overall GHG emissions of the state if the Boreal Forest is considered a managed forest, and hence, an anthropogenic source of emissions. Determination of coverage of carbon fluxes in the boreal forest as part of the Alaska GHG Inventory and Forecast. *Action Type: Education/Outreach. Cross-Cutting Topics: Overarching.*

## Specific Research Needs

Specific research needs are discussed in more detail in the appendix.

### 4.3.2 EPA Compliance/Public Health

#### 4.3.2.1 **In an arctic climate wood burning appliances need testing for particulate matter (PM), nitrogen oxides (NOx) and carbon monoxide (CO) to ensure**

**public health is not negatively impacted. Demonstrate that in arctic weather conditions, modern wood combustion appliances, such as wood pellet stoves, boilers and larger scale wood chip or co-fire facilities meet Environmental Protection Agency (EPA) particulate matter (PM-2.5) and other pollutant standards. This is very important for the communities of Fairbanks and Juneau which have been in violation of the new PM-2.5 standard and may have wood burning closures to help deal with the issue.**

Like other combustion systems wood boilers emit a variety of pollutants, including particulate matter, nitrogen oxides, carbon monoxide, volatile organic compounds (VOC), sulfur dioxide (SO<sub>2</sub>), carbon dioxide (CO<sub>2</sub>) and other pollutants. Wood boilers emit PM, NO<sub>x</sub>, and CO in much greater quantities than the other pollutants. For this reason, these are the three pollutants to track and carefully monitor to determine potential impacts. Wood systems also emit greater quantities of CO<sub>2</sub>, however unlike fossil fuels; woody biomass is considered carbon neutral. **Action Type: Modeling, Products, Education/Outreach, Monitoring. Cross-Cutting Topics: Natural Systems.**

### 4.3.3 Carbon Cycle

#### 4.3.3.1 Develop a protocol that assigns a carbon life to different types of wood products, including durable wood products.

In most models that portray carbon flux between sinks and sources there is currently no allocation made for carbon storage as a tree moves from a log to a forest product. When the tree is harvested from the forest, it is treated as an emission. This is a simplification that is not accurate in the real world use of wood. Products substitution (using wood instead of steel, concrete or other building products) can have much higher carbon footprint than wood. Life cycle assessment studies have conclusively shown marked differences in energy requirements associated with different building materials and structures made from them, yet current carbon trading protocols don't make allowances for this type of sequestration or reduction of GHG emissions. **Action Type: Modeling, Data Management. Cross-Cutting Topics: Natural Systems.**

#### 4.3.3.2 Determine if woody biomass used in energy production is a carbon-neutral fuel source. Scientifically demonstrate that woody biomass used as a fuel for energy is a carbon-neutral fuel.

Currently woody biomass is considered a carbon neutral fuel when compared to fossil fuels, such as coal, oil or natural gas. The combustion of all fuels produces CO<sub>2</sub>, but trees that are harvested for this purpose are replaced by new trees that sequester carbon from the atmosphere. Over time, the CO<sub>2</sub> released by the combustion process will be captured again by the new tree crop. This concept is important because in the carbon trading market place, an offset credit can be

generated by using a biomass fuel for a fossil fuel. It is a straight forward calculation to determine how much C is in a gallon of fuel oil or ton of coal and when you "offset" this fuel type with biomass you generate a credit that can be sold. **Action Type: Modeling, Data Management. Cross-Cutting Topics: NA.**

## 4.4 Oil and Gas (OG) TWG

The Oil and Gas Technical Work Group was tasked with developing recommendations for policies and actions to reduce GHG emissions related to the oil and gas industry in Alaska. Of the 52 MMT gross CO<sub>2</sub>/yr emissions in Alaska, the oil and gas industry produces 15 MMT, 12 MMT of which are from the North Slope, the majority from Prudhoe Bay. Recognizing that although most of the recommendations focus on the North Slope and Prudhoe Bay, many of the principles can also be applied to the Cook Inlet and other oil and gas operations. Additionally, this TWG was tasked to address Carbon Capture and Sequestration (CCS) research needs both within and outside oil and gas facilities.

### **TWG Recommendations**

The TWG's principal working mitigation options being worked at this time are:

- OG-1. Evaluate reductions in GHG that can be related to overall conservation activities, i.e. reducing liquid fuel consumption, minimal venting, and other best practices.
- OG-2. Reduce fugitive methane emissions (emissions due to leaks.)
- OG-3. Electrification of Oil and Gas Operations, with Centralized Power Production and Distribution
- OG-4. Improved Efficiency Upgrades for Oil and Gas Fuel burning Equipment
- OG-5. Use of Renewable Energy Sources in Oil and Gas Operations
- OG-6. Carbon capture and sequestration from high CO<sub>2</sub> fuel gas. Use of CO<sub>2</sub> for enhanced oil recovery.
- OG-7. Carbon capture and sequestration from exhaust gas at Prudhoe Bay. Use of CO<sub>2</sub> for enhanced oil recovery.
- OG-8. Carbon capture and sequestration from exhaust gases away from existing oil and gas fields.

### **RNWG Recommendations**

To these policy options the following additions are recommended:

#### **Identify critical infrastructure risks associated with:**

- OG-9. Changes in permafrost
- OG-10. Changes in surface and subsurface hydrology
- OG-11. Sea level changes
- OG-12. Changes in habitat and wetlands
- OG-13. Changes in length of operational season
- OG-14. Coastal erosion from reduced sea ice during storm season

- OG-15. Changes in shipping scenarios
- OG-16. Data sets, maps, and digital information needed for long term monitoring and forecasting of environmental change
- OG-17. Engineering change needed in operations, i.e., platform design

#### **Economic**

- OG-18. Short and long term value of carbon
- OG-19. Short and long term value of natural gas
- OG-20. Impact of various incentives to major capital improvement investment
- OG-21. Potential impact of carbon mitigation efforts on royalty revenue stream coming to the State of Alaska from oil and gas production

#### **General infrastructure and baseline data needs**

- OG-22. Bathymetry and detailed Digital Elevation Model (DEM) information
- OG-23. Regionally appropriate baseline physical mapping and imagery including bathymetry
- OG-24. Regionally appropriate baseline mapping and monitoring of surface and subsurface (groundwater) hydrology

### **Research Needs**

There are some significant research topics that should be pursued, and they are segregated between the reactionary and proactive realms. On the reactionary front, there must be analysis of how various policies will affect the ultimate recovery of the state's resource given some economic threshold. Secondly, analysis must be done on a "bang for the buck" scale that at least addresses an economic prioritization of research topics. Ultimately, it is critical that much of the available time and capital be spent pursuing 'low hanging fruit', and only minimal effort be expended on those projects that will produce minimal reductions.

On the proactive front, there should be vigorous research on new energy technologies and efficiencies, and incorporating long-term renewable energies into the huge energy sink of producing oil. This only makes sense from the standpoint of maximizing the sale of the transportable energy by exploiting local renewables that cannot be easily exported.

Finally, small advances in technology can have the greatest affect on aged developments, especially if those assets have experienced minimal modernization and upgrade during their history. Focusing a reasonable portion of research on new innovations to old equipment and methods has the capability of reaping the strongest benefit.

#### **4.4.1 Overarching Research Needs**

Overarching research needs for the Oil and Gas TWG activities include:

**4.4.1.1 Economic: Investigate impact of various incentives to major capital improvement investments.**

This is an issue because incentives will drive a significant amount of private sector investment to reduce overall emissions and improve energy efficiency. **Action Type: Modeling. Cross-Cutting Topics: Energy supply and demand**

**4.4.1.2 Economic: Assess short and long term value of carbon and determine whether the state may benefit from proactive carbon policies.**

Understanding the value of carbon will be critical in developing reasonable and effective policy for all CO2 mitigation activity. These values will also be used to assess the economic impact of CO2 mitigation on the state's economic future. Many states are now developing local policy in the forefront of federal regulation. Alaska should evaluate this option carefully and determine whether some level of control can be attained by proactive policy measures. **Action Type: Modeling. Cross-Cutting Topics: Overarching**

**4.4.1.3 Economic: Determine potential impact of carbon mitigation efforts on royalty revenue stream coming to the State of Alaska from oil and gas production.**

Carbon mitigation costs will have a detrimental effect on the ultimate recovery of oil and gas in the state because of the impact on production costs and reduction of economically recoverable oil and gas. This impact is potentially quite large for some of the depleted fields. **Action Type: Modeling. Cross-Cutting Topics: Overarching**

**4.4.1.4 Technical: Develop regionally appropriate baseline mapping and monitoring of surface and subsurface (groundwater) hydrology.**

Most areas of the state do not have adequate data on hydrology and what the affects development might have on requirements and impacts of surface and subsurface water resources. **Action Type: Modeling, Education/Outreach, Monitoring. Cross-Cutting Topics: Overarching**

**4.4.1.5 Technical: Develop regionally appropriate baseline physical mapping and imagery including bathymetry.**

Nearly all modern research efforts must be based on a solid foundation of baseline topographic and attribute mapping in order to achieve the level of resolution needed. It is difficult to perform modern analyses without up-to-date DEMs, orthoimagry, and detailed geologic mapping. Unfortunately, Alaska is woefully lacking in much of this most basic information, and when compared to all other states, and most other countries, Alaska is literally in the "dark ages" when it comes to baseline data. **Action Type: Products, Data Management, Monitoring. Cross-Cutting Topics: NA**



#### **4.4.1.6 CO2 storage: Evaluate capacity of geologic and biologic sequestration in different regions of the State of Alaska.**

Depending on what type of reductions mandates are adopted, understanding the capacity and location of viable storage sites is critical. It is equally important that regulations and legal liabilities are developed and identified prior to the planning and implementation of long-term storage activities. *Action Type: Modeling, Education/Outreach. Cross-Cutting Topics: Overarching, Energy supply and demand.*

### **Specific Research Needs**

Specific research needs are discussed in more detail in the appendix.

#### **4.4.2 Economic**

##### **4.4.2.1 Assess short and long term value of natural gas. Understanding the value of natural gas will allow a comparison of other forms of power generation at operations and will drive investment decisions on energy source.**

Action Type: Modeling. Cross-Cutting Topics: Energy supply and demand

#### **4.4.3 CO2 Storage**

##### **4.4.3.1 Evaluate enhanced hydrocarbon recovery options using CO2 flooding and pressure support.**

Enhanced Hydrocarbon recovery is one of the only CCS methods that derives economic benefit from the activity and increases ultimate recovery of a resource for the State. *Action Type: Modeling. Cross-Cutting Topics: NA*

##### **4.4.3.2 Evaluate the feasibility of saline reservoir sequestration in non-marine basins prevalent throughout Alaska.**

CO2 storage in saline reservoirs may become an issue in Alaska after conventional reservoirs are saturated or in areas where no convention reservoirs exist (e.g., interior Alaska). *Action Type: Modeling, Monitoring. Cross-Cutting Topics: NA*

#### **4.4.4 Technical**

##### **4.4.4.1 Evaluate the feasibility of various entrained and exhaust CO2 capture technologies for North Slope and Cook Inlet.**

Capturing CO2 from various exhaust systems will be a challenging effort and will need many new technologies. *Action Type: Products. Cross-Cutting Topics: Energy supply and demand.*

#### **4.4.4.2 Study where renewable energy sources co-exist with oil and gas operations.**

Renewables may be able to play a significant role in the portfolio of supplying energy for operations. **Action Type: Products, Education/Outreach. Cross-Cutting Topics: Energy supply and demand.**

## **4.5 Transportation and Land Use (TLU) TWG**

The Transportation and Land Use TWG assessed to potential areas in transportation and land use where GHG emissions can be reduced. Actions by the state are identified that include education, planning, and regulations.

### **TWG Recommendations**

The TWG forwarded the following adaptation policy options for consideration by the Climate Change Sub-Cabinet:

- TLU-1. Transit, Ridesharing, and Commuter Choice Programs
- TLU-2. Vehicle Idling Regulations and/or Alternatives
- TLU-3. Transportation System Management
- TLU-4. Promote Efficient Development Patterns (Smart Growth)
- TLU-5. Promotion of Alternative Fuel Vehicles
- TLU-6. Vehicle Mile Travelled and Greenhouse Gas Reduction Goals in Planning
- TLU-7. On-Road Diesel Engine Efficiency Improvement
- TLU-8. Marine Vessel Efficiency Improvements
- TLU-9. Aviation Emissions Reductions
- TLU-10. Alternative Fuel Research and Development

### **RNWG Recommendations**

To these policy options the following addition is recommended:

- TLU-11. Systematically identify and address economic barriers to implementing climate change planning efforts.

## **Research Needs**

### **4.5.1 Overarching Research Needs**

Overarching research needs for Transportation and Land Use TWG activities include:

#### **4.5.1.1 Develop statewide tools for planning.**

Need statewide planning tools to systematically evaluate GHG emissions on future scenarios. Priority: High. Urgency: Planning tools can provide the most benefit if

they are immediately available. Activity type: Modeling, Products. Cross-Cutting Topics: NA

## Specific Research Needs

### 4.5.2 Fuels

#### 4.5.2.1 An essential research need is to understand carbon cycle from cradle to grave to see if reducing tail pipe emissions is worthwhile.

The carbon-cost of creating fuel needs to be included in the evaluation. Decision makers need complete information to make valid data driven decisions. If only part of the carbon cycle is considered, the economics of decisions may not be realistic. *Activity type: Modeling, Products. Cross-Cutting Topics: NA*

**4.5.2.2 There is a need to analyze the life-cycle GHG impacts of various alternative fuels in the Alaska context.** The life-cycle GHG impacts of alternative fuels depend heavily on emissions from fuel production and transport. Nearly all research to date has focused on the lower 48. GHG impacts in Alaska could be quite different. Need to understand which alternative fuels have GHG benefits in AK. *Activity type: Modeling. Cross-Cutting Topics: NA*

### 4.5.3 Transportation Planning

#### 4.5.3.1 Develop methods or tools to accurately estimate GHG impacts of transportation plans in Alaska.

Transportation agencies will soon be required to quantify GHG impacts of transportation plans. Tools and methods are being developed for lower 48. But arctic climate in AK might affect the GHG emissions from motor vehicles and necessitate tools or methods that are adapted to AK. *Activity type: Modeling, Products. Cross-Cutting Topics: NA*

#### 4.5.3.2 Investigate potential to reduce fuel use and GHG emissions by coordinating transportation networks and commercial fishery openings.

Excess fuel use and GHG emissions occur because of poor coordination of fishery openings. Priority: *Activity type: Modeling, Monitoring. Cross-Cutting Topics: NA*

### 4.5.4 Marine Vessels

#### 4.5.4.1 Determine GHG impacts of replacing older marine vessel engines with newer engines.

Newer marine engine have lower particulate matter emissions due to federal standards. But their effect on GHGs is uncertain. *Activity type: Modeling. Cross-Cutting Topics: NA*

## 4.5.5 Aviation

### 4.5.5.1 Evaluate the actual reduction of GHG from a pilot study of continuous descent approaches to Ted Stevens International Airport.

Aviation in Alaska has a disproportionate impact on GHG emissions compared to other forms of transportation. Focusing on aviation reductions may be an area where large reductions can be realized. **Activity type: Modeling, Monitoring.**  
**Cross-Cutting Topics: NA**

## 4.5.6 Public Transportation

### 4.5.6.1 Conduct analysis to determine what is required to increase citizen use of public transportation and increase conservation efforts.

Need to understand what actions by the government result in greater use of public transportation and greater conservation efforts. **Activity type: Education/Outreach.**  
**Cross-Cutting Topics: NA**

# 5 Recommendations: Adaptation

## Adaptation Technical Workgroups

The Adaptation Advisory Groups (AAG) was tasked with identifying policy recommendations that could be implemented to help Alaska adapt to a changing environment resulting from climate change impacts. Four technical workgroups (TWGs) were formed as part of the AAG:

- Economic Activities
- Health and Culture
- Natural Systems
- Public Infrastructure

### 5.1 Economic Activities (EA) TWG

The Economic Activities TWG evaluated the effects of climate change on a wide range of economic activities across Alaska. They focused on oil and gas, renewable energy, mining, ocean transportation, rural non-road transportation, transportation and recreation, boundaries and ownership, energy demand, evolving jobs and economy, information collection and dissemination, and other economic sectors.

#### TWG Recommendations

The TWG forwarded the following adaptation policy options for consideration by the Climate Change Sub-Cabinet:

- EA-1. Evaluate potential needs for expanded ocean oversight and regulatory activities
- EA-2. Explore economic activity opportunities offered by climate change
- EA-3. Develop scenarios for the Alaska economy affected by climate change
- EA-4. Establish a center for knowledge sharing on Arctic issues
- EA-5. Improve availability of mapping, surveying, charting, and imagery data

#### RWNG Recommendations

To these policy options the following addition is recommended:

- EA-6. Systematically identify and address economic barriers to implementing climate change planning efforts

- EA-7. Evaluate full-cycle economic impact of mitigation and adaptation proposals in relation to ultimate cost of energy, state revenue income stream, required state and federal subsidies, and local economic impact to businesses reliant on existing infrastructure.

## Research Needs

### 5.1.1 Overarching Research Needs

Successful implementation of these policy options will require baseline data collection, scenario modeling, monitoring and assessment. Many of these research needs overlap those identified by other TWG, in that economic factors form a common thread. Overarching research needs for economic activities include:

#### 5.1.1.1 Develop higher resolution climate modeling and monitoring data and improve its accessibility and utility.

This need is common among nearly all the TWG. To assess and plan for changing economic conditions as a result of a changing climate will require higher resolution climate modeling and monitoring information at more local levels. Additionally, there is a need to increase the accessibility and utility of these data to government officials and businesses. Finally, there is a need to tailor these data to the needs of government officials and businesses. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: All**

#### 5.1.1.2 Assess statutory, regulatory, and policy frameworks and barriers to implementing climate change policy recommendations.

Many laws, regulations and policies on the federal, state, and local levels were developed before the signs of more rapid climate change were recognized. For example, resource managers in Alaska may need to revise Alaska policies relative to wildland fire management in light of the effects of climate change. Another example is the need to modify water quality standards that call for maintenance of water temperatures in cold water systems in light of warming temperature. The challenge for government leaders and businesses will be to adapt to a future made less certain due to a more rapidly changing climate. This will necessitate an evaluation of existing laws, regulations and policies and possible changes to institutional, legal and policy frameworks in an adaptive manner. **Action Type: Products, Education/Outreach. Cross-Cutting Topics: All**

**5.1.1.3 Assess economic impacts of market-based approaches (e.g., cap and trade) to manage greenhouse gas (GHG) emissions and their impacts on the Alaskan economy.**

Market-based approaches to manage GHG emissions can have a significant impact on many aspects of the Alaskan economy. It will be imperative to track these approaches as they develop and to proactively formulate strategies to adopt state approaches and, if necessary, adapt to adopted approaches. **Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: All**

**5.1.1.4 Systematically identify and address economic barriers to implementing climate change planning efforts.**

Uncertainty associated with climate change may result in barriers to implement identified climate change strategies/options and planning efforts. It is important to identify these barriers and strategies for addressing them. The uncertainty and risk of the current predictions should be well understood and incorporated in the decision process. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: All**

**5.1.1.5 Assess data and information (economic indicators) needed to develop or adapt short and long term planning tools to assess impacts of climate change on economic activities.**

There is a lack of baseline economic information and data needed to develop or adapt both short and long term planning tools to implement identified climate change strategies and options. It is critical to identify and collect the needed economic indicators. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: All**

**5.1.1.6 Implement adaptive (scenario-based) planning tools that integrate economic indicators to improve climate change mitigation and adaptation decision-making and implementation.**

Successful implementation of climate change strategies/options will require development and implementation of adaptive planning tools. These tools need to be probabilistic and scenario-based and integrate economic indicators. **Action Type: Products, Education/Outreach, Monitoring. Cross-Cutting Topics: All**

**5.1.1.7 Catalog and assess new or expanded economic opportunities that may become available with climate change.**

While some existing economic activities may be deleteriously affected by a changing climate, others may be benefited while still others may become established. For example, a warming climate may open new economic opportunities in the Arctic basin, including commercial fishing and transpolar shipping. A necessary first step towards developing these opportunities is to catalog and assess them. **Action Type: Products, Education/Outreach. Cross-Cutting Topics: All**

## Specific Research Needs

Specific research needs by economic activity research area are presented below by sector. They are discussed in more detail in the appendix.

### 5.1.2 Oil and Gas

#### 5.1.2.1 Develop economic analysis of potential rise or decline of oil and gas development on state revenues.

Oil and gas production provides significant revenues to Alaska. As such, any changes to oil and gas production can be expected to have significant impacts to the Alaskan economy. Climate change and resultant efforts to mitigate for it, or adapt to it, is expected to have impacts to oil and gas production. For example, development of cap and trade programs could have significant impacts on oil and gas production. Given the likelihood of such impacts it is imperative to develop economic analysis of potential rise or decline of oil and gas development on state revenues. **Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: Oil and Gas**

#### 5.1.2.2 Consider how potential rise or decline of oil and gas operation and maintenance may affect state revenues.

Climate change is expected to have impacts on oil and gas operations and maintenance. Under current tax structures, operation and maintenance costs can influence the amount of revenue the state receives from production. For this reason, it is important to determine how potential rise or decline of oil and gas operation and maintenance may affect state revenues. **Action Type: Modeling, Products, Education/Outreach, Monitoring. Cross-Cutting Topics: Oil and Gas**

#### 5.1.2.3 Model coastal vulnerability to establish criteria for pipeline coastal transition set-backs and burial depths.

Climate change is expected to impact coastal zones through erosion and coastal inundation. This will require an assessment of the current permitting and oversight of pipelines and other operations in the coastal zone. This assessment will require a modeling of coastal vulnerability to establish criteria for pipeline coastal transition set-backs and burial depths. **Action Type: Modeling, Products, Education/Outreach, Monitoring. Cross-Cutting Topics: Public Infrastructure and Oil and Gas**

#### 5.1.2.4 Expand research on ice road and pad construction techniques and in-season monitoring to maximize seasonal use and minimize impacts.

Climate change is impacting the length of time ice roads and pads can be used on the North Slope of Alaska. Expanded research on ice road and pad construction techniques and in-season monitoring is needed to maximize seasonal use and minimize impacts. **Action Type: Modeling, Products, Education/Outreach, Data**



**Management, Monitoring. Cross-Cutting Topics: Public Infrastructure and Oil and Gas**

**5.1.2.5 Expand research on climate change impacts on permafrost engineering design.**

Permafrost is being impacted by climate change. These impacts are affecting existing and planned structures. Design standards are inadequate to address these impacts. Expanded research on climate change impacts on permafrost engineering design is needed. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: Public Infrastructure and Oil and Gas**

**5.1.2.6 Develop new techniques to clean up oil spills in icy waters.**

There is an interest in developing offshore oil and gas in Arctic areas. This increases the potential for oil spills in offshore areas that are being impacted by changing ice conditions associated with climate change. There is a need to develop new techniques to plan for and clean up oil spills in icy waters. **Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: Oil and Gas**

**5.1.3 Renewable Energy**

**5.1.3.1 Assess economic potential for developing carbon-neutral energy sources.**

Federal legislation may likely call for a larger proportion of energy production to come from carbon-neutral sources (definition, e.g. including forest materials). In Alaska, little is known about the economic potential for developing carbon-neutral energy sources. Given this, it is imperative to assess the potential for developing carbon-neutral energy sources. **Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: Energy Supply and Demand**

**5.1.3.2 Identify potential economies of scale and return on investments in developing renewable energy sources.**

Little is known about the long-term economics associated with renewable energies. As there is an increased call for shifting energy production to renewable energy sources it is important to identify potential economies of scale and return on investments in developing renewable energy sources. This will allow better decision tools to be developed to inform the economic impacts of renewable energy sources. **Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: Energy Supply and Demand**

## 5.1.4 Mining

### 5.1.4.1 Research cost-effective techniques for construction, operation, and reclamation that will be responsive and useful in changed environmental conditions.

Energy conservation and renewable energy alternatives require metals and metal alloys. As renewable energies increase, this will increase the demand for metals. Since Alaska has world class metal resources, it can be expected that there may be increased interest in mining. It will be important to research cost-effective techniques for construction, operation, and reclamation that will be responsive and useful in changed environmental conditions. **Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: Public Infrastructure, Natural Systems, Energy Supply and Demand.**

### 5.1.4.2 Assess engineering standards for tailings storage in Arctic/Subarctic climates.

Energy conservation and renewable energy alternatives require metals and metal alloys. As renewable energies increase, this will increase the demand for metals. Since Alaska has world class metal resources, it can be expected that they will be increased interest in mining. As new mines are developed it will be important to assess engineering standards for tailings storage in Arctic/Subarctic climates. **Action Type: Modeling, Products, Education/Outreach, Monitoring. Cross-Cutting Topics: Public Infrastructure, Natural Systems, Energy Supply and Demand**

### 5.1.4.3 Develop economic analyses of potential rise or decline of mining and impact on state revenues.

Energy conservation and renewable energy alternatives require metals and metal alloys. As renewable energies increase, this will increase the demand for metals. Since Alaska has world class metal resources, it can be expected that they will be increased interest in mining. As this demand increases it will be important to develop economic analyses of potential rise or decline of mining and impact on state revenues. **Action Type: Modeling, Education/Outreach, Monitoring. Cross-Cutting Topics: Public Infrastructure, Natural Systems, Energy Supply and Demand**

## 5.1.5 Ocean Transportation

### 5.1.5.1 Model sea ice and its effect on ocean transportation.

Climate change is reducing sea ice in the Arctic at varying rates. It is important to model sea ice and its effect on ocean transportation. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: Natural Systems, Public Infrastructure**

**5.1.5.2 Develop economic analysis of potential rise or decline of shipping and impact on state revenues.**

Climate change is reducing sea ice in the Arctic, creating economic opportunities and localized costs. It is important to assess the impacts of increased shipping to Alaska and its economy. **Action Type: Modeling, Products, Education/Outreach, Monitoring. Cross-Cutting Topics: Natural Systems, Public Infrastructure**

**5.1.5.3 Identify trends that may influence impacts of shipping on the environment, hunting, fishing and communities.**

Climate change is reducing sea ice in the Arctic and allowing for increased shipping. This will potentially influence the environment, hunting, fishing and coastal communities. As such it is necessary to identify trends that may influence impacts of shipping on the environment, hunting, fishing and communities. **Action Type: Modeling, Products, Education/Outreach, Monitoring. Cross-Cutting Topics: Natural Systems, Public Infrastructure**

**5.1.5.4 Increase ice-breaking capabilities in the Arctic.**

Climate change is impacting the formation and breakup of sea ice in the Arctic. To increase the duration of shipping and provide for assistance in sea ice conditions, ice-breaking will be required. For these reasons it is imperative to Increase ice-breaking capabilities in the Arctic. **Action Type: Modeling, Products, Monitoring. Cross-Cutting Topics: Public Infrastructure**

**5.1.5.5 Research innovative approaches and building techniques for supporting arctic shipping and developing sustainable ports.**

Climate change is changing sea ice formation and breakup in the Arctic, which will change how ports are developed and shipping routes maintained. This will require research into innovative approaches and building techniques for supporting arctic shipping and developing sustainable ports. **Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: Public Infrastructure**

**5.1.6 Rural Non-Road Transportation**

**5.1.6.1 Assess the impact of climate change on existing rural transportation networks.**

Much of Alaska's rural transportation network is non-road based, depending on frozen tundra and unfrozen river and lake routes for surface transportation. As a result, climate change can potentially significantly affect these networks. For these reasons, it is imperative to assess the impact of climate change on existing rural transportation networks. **Action Type: Modeling, Products, Education/Outreach, Monitoring. Cross-Cutting Topics: Public Infrastructure and Health and Culture**

#### **5.1.6.2 Develop economic analysis of potential costs associated with expected impacts to rural transportation networks.**

Much of Alaska's rural transportation network is non-road based. As a result, climate change can potentially significantly affect these networks. With increases to costs of transportation, it is important to develop economic analysis of potential costs associated with expected impacts to rural transportation networks. **Action Type: Modeling, Products, Education/Outreach, Monitoring.** **Cross-Cutting Topics: Public Infrastructure and Health and Culture**

### **5.1.7 Other Economic Sectors**

#### **5.1.7.1 Develop economic analysis of potential rise or decline of recreational, subsistence and commercial fishing.**

Climate change will impact fish and their habitats to varying degrees. Some fisheries will benefit while others will be negatively impacted. Research into fisheries should support economic analysis of the potential rise or decline of recreational, subsistence and commercial fishing. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring.** **Cross-Cutting Topics: Natural Systems, Health and Culture**

#### **5.1.7.2 Assess and model increased insurance costs.**

Climate change is recognized as causing increased risks to private and government infrastructure. Insurance premiums are based on environmental conditions and projected risks. It will be important to assess and model insurance costs associated with risks perceived from climate change influences. **Action Type: Modeling, Products, Education/Outreach.** **Cross-Cutting Topics: Public Infrastructure and Health and Culture**

### **5.1.8 Transportation and Recreation**

#### **5.1.8.1 Develop economic analysis of potential rise or decline of tourism and impact on state revenues.**

Tourism is an increasing contributor to the Alaskan economy. It is unknown how a changing climate may impact tourism. It is important to develop economic analysis of potential rise or decline of tourism and impact on state revenues related to climate change. **Action Type: Modeling, Products, Education/Outreach.** **Cross-Cutting Topics: Natural resources, Public Infrastructure, Health and Culture**

#### **5.1.8.2 Develop economic (scenario) analysis of potential national and international changes in patterns of people and freight movements.**

Climate change is impacting natural systems throughout the Arctic, both in the terrestrial and ocean areas. The impact to these natural systems will likely change the patterns of movement of people and freight. It is important to develop

economic (scenario) analysis of potential national and international changes in patterns of people and freight movements. **Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: Natural resources, Public Infrastructure, Health and Culture**

#### **5.1.8.3 Assess opportunities for development/enhancement of recreation due to climate change.**

Climate change is impacting natural systems throughout the Arctic with changes to seasonal recreation. It is imperative to assess opportunities for development/enhancement of recreation due to climate change. **Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: Natural resources, Public Infrastructure, Health and Culture**

### **5.1.9 Boundaries and Ownership**

#### **5.1.9.1 Improve mapping and surveying to accurately and efficiently establish boundaries, address boundary disputes as needed and aid charting for safe navigation.**

As climate changes, boundaries that are dependent upon physical features may be impacted. It is necessary to improve surveying and mapping to accurately display the land and land/water interface. This will support establishing boundaries and provide data to address boundary disputes. Improved charting for safe navigation and mapping for overland travel will be an ancillary product. **Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: Natural resources, Public Infrastructure**

### **5.1.10 Energy Demand**

#### **5.1.10.1 Assess how climate change will impact application of federal, state, and local laws, regulations and policies on energy demand and use.**

Climate change legislation will impact application of federal, state, and local laws, regulations and policies on energy demand and use. For example, increased pressure to reduce GHG will have impacts on laws, regulations, and policies related to natural resources. For this reason it is imperative to assess how climate change will impact application of federal, state, and local laws, regulations and policies on energy demand and use. **Action Type: Products, Education/Outreach. Cross-Cutting Topics: All**

### **5.1.11 Evolving Alaska's Jobs and Economy**

#### **5.1.11.1 Assess how climate change will impact application of federal, state, and local laws, regulations and policies on economic development activities.**

Climate change legislation will impact application of federal, state, and local laws, regulations and policies on economic development activities. For example,

increased Arctic shipping and resource development will have impacts on laws, regulations, and policies related to natural resources and indigenous people. For this reason it is imperative to assess how climate change will impact application of federal, state, and local laws, regulations and policies on economic development activities. **Action Type: Products, Education/Outreach. Cross-Cutting Topics: All**

## 5.1.12 Information Collection and Dissemination

### 5.1.12.1 Continue to refine the “Cost of Climate Change” study recently completed by the UAA ISER.

The University of Alaska Institute of Social and Economic research is conducting a study to assess the costs of climate change to Alaska. This is an overarching economic analysis of the climate related impacts. This study should be completed. **Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: All**

### 5.1.12.2 Identify climate trends and downscale models leading to establishing environmental information, analysis tools, and design criteria for use in adapting to climate change.

This need is common among nearly all the TWG. To assess and plan for changing economic conditions as a result of a changing climate will require higher resolution climate modeling and monitoring information at more local levels. Additionally, there is a need to increase the accessibility of these data to government officials and businesses. Finally, there is a need to tailor these data to the needs of government officials and businesses. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: All**

### 5.1.12.3 Provide resources for good Digital Elevation Model (DEM) and GIS data, and current and high resolution imagery to establish a more robust information infrastructure to plan and adapt.

There is a need for improved Digital Elevation Model (DEM) and GIS data, and current and high resolution imagery to establish a more robust information infrastructure to plan and adapt. This information is needed to develop down-scaled models and to assess potential economic impacts. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: All**

### 5.1.12.4 Invest in monitoring and data dissemination programs to enhance information available for safe and efficient resource development.

Much data is currently available but for a variety of reasons is unavailable to researchers or decision-makers. There is an urgent need to invest in monitoring and data dissemination programs to enhance information available for safe and efficient resource development. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: All**

## 5.2 Health and Culture Research Needs (HC) TWG

Health and Culture can be divided into two research focuses, i.e. health which researches the risks associated with a changing climate and communities and culture which researches the risk to losing that which has endured and evolved with the people, their traditions and knowledge.

### **TWG Recommendations**

The TWG forwarded the following adaptation policy options for consideration by the Climate Change Sub-Cabinet:

- HC-1. Identify a central agency, as well as responsible individuals, to support rural communities in dealing with complex issues requiring coordination among multiple state and federal agencies, local governments, NGOs, and others.
- HC-2. Augment surveillance and control programs for vector-, water-, and foodborne diseases likely to become greater threats because of climate change. Develop educational programs for the public, health care providers, environmental staff, and others on approaches to reduce emerging disease threats.
- HC-3. Initiate a community health impacts evaluation mechanism to evaluate recommended adaptation and mitigation options to determine whether they could result in adverse health impacts and, if so, to recommend approaches to reduce these risks.
- HC-4. Assess risks to rural sanitation and solid waste management from flooding, thawing permafrost, and other risks, or that is otherwise subject to changed conditions that significantly reduce performance in environmental health protection. Consider the modification, rebuilding, or relocation of sanitation infrastructure to protect human and environmental health.
- HC-5. Assess archeological, historical, and cemetery sites at risk from climate change. In cooperation with appropriate local, regional, and statewide entities, assess archaeological sites at risk from accelerated coastal and river erosion; convene archaeologists, anthropologists, Alaska Native elders, and others to discuss how best to address and prioritize sites at risk; and develop a plan for the protection or recovery of important at-risk sites. Complete a statewide assessment of the gravesites most at risk; assist in identifying and opening new gravesites; convene a respectful discussion about gravesites and explore best practices; provide assistance for the relocation of existing at-risk gravesites.

### **RNWG Recommendations**

To these policy options the following addition is recommended:

- HC-6. Research mechanisms to insure that traditional knowledge and wisdom is integrated into research programs and research results are corroborated in understanding the climate change impacts to and opportunities for indigenous people and their culture.

## Research Needs

### **Background for health research needs**

Sentinel events and indicators will show risks to public health and indigenous people and fauna in areas where the climate is changing at an accelerated rate. The research must help to understand the exposure-response relationship associated with the indicator and the potential duration and extent of the event. This research will help to understand the link between the change happening and the potential risks beyond the sentinel event so that health models can be developed and risks estimated.

Health models will need to be refined to propose response to the sentinel events and account for risks to the health of the residents and the flora and fauna in the adjoining ecosystem. The models should provide a scientific methodology for conducting surveillance and establishing control in response to a “sentinel event”. The models must be clear enough to enable local collection of health information that will fit into the scientific methodology and yet allow flexibility to researchers to adapt the research strategy and health models to accurately portray and understand the sentinel event and its link to changes in climate and environment.

Health impact assessments will be an essential research tool to adjusting the models to the indicators of sentinel events and the changes to health that are associated with changing climates and escalation of health risks with the sentinel event. How this happens and what happens over the duration of the event will need a monitoring protocol that is consistent with the scientific methodology yet designed for collection by the local health community members. Meeting this research component will allow the databases to be expanded on a community by community basis and refine the health impact assessments to address specific community needs.

The research matrix required in understanding the health risks associated with climate change must assess the factors causing the sentinel event. This should include, but not be limited to whether it is a water, food, insect or vermin borne vector. The matrix should recognize whether the event is part of range extension, as may be shown with ichthyophonus or paralytic shellfish poisoning in fish and shellfish, wasting disease in the fauna, or tumors, asthma or infection in the people. This information will portray impacts on the physical and mental health of the people. It is at this point where health and culture research come together in a research matrix approach, as the health is directly linked to the subsistence culture and social well being of a traditional lifestyle.

### **Background for culture research needs**

Research protocols that document the social impacts to community life of climate change are essential in addressing the questions of adaptation. Through the use of community social and health services, a research protocol can be implemented that meets the scientific needs while recognizing the communities’ capabilities and insight. This includes the



integration of traditional knowledge and wisdom into the research questions so as to insure that what is seen is consistent with what is measured.

A standardized social network approach to research is recommended. This will allow consistency with research in other socio-cultural programs while allowing the research to adapt to the uniqueness of changes within the last generation. The social network will provide the data needed to identify communities at risk and the risks that are affecting the communities in the short and long term.

Modeling local economies from the standardized social network data will help in addressing the social and cultural impacts of climate change and link back to health risks. This will focus on the people and the community. Additional research will be needed to model the potential for a sentinel event or the probability of a failure in the solid waste and sanitation.

Monitoring will remain an essential part of the cultural research as it pertains to changes in cultural activities, accuracy and applicability of traditional knowledge, risks from failure of community sanitation, and occurrence and trends in vector borne illnesses. Such monitoring will provide the data to refine the models that can predict the sustainability of the communities and survivability of the traditional ways.

Research protocols must be designed to document and preserve the culture, including cultural and historic artifacts. This research should focus on preserving community identity while protecting the importance to the people and confidentiality allowed by law. Efforts should be included to continue to preserve the historic stories and catalog language as a means to insure that future researchers can understand the cultures of Alaska before technology and loss to climate change.

Correlation and verification of western science with traditional knowledge and wisdom and traditional ecological knowledge will be an integral part of the research protocols and outcomes. Specifically, this correlation and verification will focus on documenting the impacts of climate change on the cultures through loss of sea ice, change in subsistence living, and deterioration of subsistence foods. While western science can document the change, this research must link to that observed by the people in their communities and how today under climate change is different than that learned from their elders.

Research should also build upon long term research as collected by state and federal agencies, e.g. ADF&G Harvest Surveys. Continuing and expanding the analyses of this and comparable other data sets can provide the western science needed to understand how the changes are observed by the people and integrated into the culture.

Socio-economic research, like the ADF&G Harvest Surveys but across the other state and federal agencies, is an integral part of the research strategy that will deliver the reports upon which the impacts of climate change can be assessed. A statewide socio-economic research plan should be developed that encompasses the breadth of climate change on Alaska's culture and the local economies. This should include a structured dialog that

strengthens the understanding of the elders in providing traditional knowledge with the data collection and research protocols of modern science.

Within the questions of socio-economic research is the impacts of public policy on community sustainability. Research questions transcend the impacts of climate change to the issue of if public policy allowing action to protect the communities, allow subsistence lifestyles to continue, and allow timely adaptation to climate related events. Research into whether barriers to adaptation exist due to present laws and/or public sentiment. Assessing whether the regulatory framework for the harvest of flora and fauna, adapting infrastructure to protect in place or relocate, and insuring community health and sustainability is adequate or counter-productive will need information based on accurate research. An interagency research team may prove an effective tool for addressing such questions.

Research needs for health and culture also cross-cut to many of the other research needs, as assessing health risks and sustaining culture depend on having the same information as other research disciplines in adapting to climate change. Cross-cutting research needs can be characterized as:

Researchers need improved cross-agency coordination. Research to address climate change impacts on health and culture will benefit from research conducted to address questions in other disciplines. Methods to improve cross agency coordination and data sharing are identified in every discussion of research needs in adapting Alaska communities to climate change. Methods often used are seminars, research meetings, web-posting, and inter-agency working groups. Cross-discipline scientific review panels can expand the dialog in finding multiple applications in understanding changes and developing adaptation strategies. Together, this can expand the breadth of research, lead to applications in other disciplines and develop response strategies for adaptation.

Research plans, projects and results need to be made available to the communities to support understanding of impacts from and options in adapting to climate change. Addressing this research need requires internet tools for distributing the information as well as improving the feedback on the value of the research project and results. Culturally tailored materials are need to reflect on traditional knowledge and wisdom (better term?) and explain how the research plan, project, and/or results will build upon the local knowledge. This will foster dialog and improve community acceptance of the results and enable adaptive planning.

Research needs include developing an education component that supports observations of indicators and monitoring of changes that may provide a basis for understanding climate impacts. Education materials are needed to support workforce development and encourage interest in local students to be involved in the science and research that is being conducted to understand climate change. This includes vocational technical training curriculum, secondary education materials, and teacher training.

Health and Culture research needs recognize the importance of having accurate materials to plan future research. This includes downscaling models to the community level for various parameters. These include ultraviolet radiation for exposure risk assessments; weather patterns and water transport for contaminants and toxin transport; and exposure to dust and methane. Health and Culture research also recognize that environmental change needs to be accurately modeled for the impacts to communities from flooding and coastal inundation and permafrost thaw, slumping and erosion. These points are clearly outside the research needs of health and culture, yet are essential in understanding the impacts of climate on health and culture.

## 5.2.1 Overarching Research Needs

Overarching research needs for Health and Culture TWG activities include:

### 5.2.1.1 **Develop regional economic models to quantify climate change impacts on communities and provide input to the NEPA process.**

Communities cannot adapt to the impacts of climate change without state and federal assistance, which requires compliance with the NEPA process and recommended alternatives. Climate change is raising significant economic questions with investment in communities and sustainability. **Action Type: Modeling, Products. Cross-Cutting Topics: Public Infrastructure and Economics**

### 5.2.1.2 **Revise Flood Risk Maps.**

Use projections for increased precipitation, loss of sea ice and the accompanied increase in storm activity over previously ice covered waters for the next 100 years to develop revised flood risk maps that will help guide communities and state agencies in making future planning and infrastructure development decisions. Allow for continual update of these maps to incorporate the expected ongoing refinement in climate projections over time. Communities cannot obtain flood insurance. Securing funding for improving and maintaining community will be difficult as lack of information and accurate data will require conservative attitudes towards investment and economic development. This will hinder economic development for the community. **Action Type: Products. Cross-Cutting Topics: Public Infrastructure and Economics and Natural Systems**

### 5.2.1.3 **Develop sea level rise projection maps for coastal areas throughout Alaska, accounting for local isostatic rebound in conjunction with global sea level rise predictions.**

Work with coastal communities and the State of Alaska to incorporate this information into community and state planning efforts to better guide future development decisions. Allow for continual update of these maps to incorporate the expected ongoing refinement in climate projections over time. Communities are unable to accurately plan for economic development and assess risks from erosion or inundation. Public is developing inaccurate perception of sea level rise

and coastal inundation because of lack of accurate information and heavy press coverage. **Action Type: Modeling. Products. Cross-Cutting Topics: Public Infrastructure and Economics and Natural Systems**

**5.2.1.4 Downscale climate modeling projections to the local or regional level to aid communities in planning.**

Alaska's communities will have significant challenges in adapting if climate modeling projections downscaled to the local or regional level are not available on which to base decisions. They will also have little incentive to adapt. Currently, Alaska Center for Climate Assessment and Policy (ACCP) has identified global circulation models (GCM) best suited to northern latitudes, and can downscale the model results to every community in the state. Disseminating this information to communities is a first step toward helping them to plan and tailor adaptation to their own specific needs and impacts. However, data gaps remain. Information on projected changes to permafrost and sea level at the local and regional levels is still lacking. Development of a statewide research grant fund could be used to focus the scientific community on filling data gaps critical to community adaptation. Develop Downscaled Climate Modeling for Municipalities.

Communities are coping with changes as seen over time while decision makers are looking for more accurate information to plan and predict actions that will be required. Research that will downscale models is identified as one solution. **Action Type: Modeling, Products, Education/Outreach, Data Management. Cross-Cutting Topics: Public Infrastructure and Economics**

**5.2.1.5 Conduct a comprehensive inventory of the wide range of data collection, monitoring efforts, and research projects underway or planned in relation to the impacts of climate change on the environment.**

The benefit to federal, state and municipal entities of having this information accessible in some form of centralized information portal, gateway, or web-based clearinghouse would be significant, most notably in terms of improved ability to make adaptation decisions intelligently and effectively. In turn, duplication of monitoring efforts could be avoided and government entities could provide feedback on specific data gaps, serving to drive future research objectives.

Conduct a Comprehensive Inventory of Current Research, Monitoring and Data Collection Efforts. Overall perception that the communities and decision makers do not have adequate information on the research projects ongoing to make plans to adapt to changing climate. There is limited understanding of the timeline by which the research will be conducted, analyzed and developed into applied research and information. With the days of Internet and modern communication technology, impacted Alaska communities need access to up to date information and the ability to help guide research projects. **Action Type Data Management, Monitoring. Cross-Cutting Topics: Mitigation All**

**5.2.1.6 Provide communities with social research on the cultural impediments and history of government.**

This research need is being addressed in the Public Infrastructure Working Group. Providing this information to communities may provide insight into how to sustain communities and maintain community infrastructure to different cultural standards, while recognizing the challenges of weather and seasons. Community-based reporting and protocols can insure longevity in public and private investment while fostering agreement to maintain systems to higher standards. Costs and sources of funding are major issues in this area. *Action Type: Modeling, Products. Cross-Cutting Topics: Public Infrastructure*

**5.2.1.7 Conduct social and education research to develop culturally appropriate curriculums for maintaining public infrastructure and community property.**

Develop economic forecast models that show the cost savings by not deferring maintenance or in determining where deferred maintenance goes from cost savings to higher costs. This is a continuation of the research needs associated with the public infrastructure TWG. *Action Type: Education/Outreach. Cross-Cutting Topics: Public Infrastructure.*

**5.2.1.8 Perform standardized social network research in select communities to understand potential impacts of relocation on social, sharing, economic and subsistence networks.**

Standardized sampling methods for social networks, as being applied in different locations and for different cultures, can provide a tool by which the challenges facing Alaska communities can be better understood. *Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: Economic Activities and Natural Systems*

**5.2.1.9 Use the SPOT satellite data system or others to track changes in permafrost extent and work to develop projection maps for changes in extent over the next 100 years, based on climate change projections.**

Satellite data and permafrost extent mapping and modeling would serve to guide communities and state agencies in construction planning decisions, both for determining the location and means of construction of new projects as well as identifying those existing projects which may be at risk from thawing permafrost in the future. Satellite data will allow for continual update of these maps to incorporate the expected ongoing refinement in climate projections over time. Communities need accurate data to understand changes to their community and surrounding environment. This will support the traditional ways of life with modern mapping products. *Action Type: Data Management, Monitoring. Cross-Cutting Topics: Public Infrastructure, Agriculture, and Economics*

**5.2.1.10 Refine global climate models for better understanding of regional variations within Alaska.**

Modeling will provide a better understanding of the effects of climate change. Improved monitoring and modeling data will allow for development and dissemination of environmental information and design criteria for use in adapting to climate change. *Action Type: NA. Cross-Cutting Topics: NA*

**5.2.1.11 Assess the degree and rate of thawing submarine permafrost deposits in coastal areas due to warming sea temperatures.**

Study of the climate-driven instability of coastal permafrost is needed to evaluate the risk of subsidence and erosion and the consequent impact on human developments and ecosystems. Newtok relocated because of the thawing of subterranean and submarine permafrost. Other coastal communities in western, northwest and northern Alaska have comparable risk with retreat of sea ice and exposure of permafrost to wind induced waves. Research to identify susceptible communities and assess the rate of permafrost loss is needed. *Action Type: Modeling, Monitoring. Cross-Cutting Topics: Public Infrastructure and Natural Systems*

**5.2.1.12 Consider developing a series of television segments for Alaska Weather that provides climate change projection information and data on issues of specific importance to Alaska's rural communities.**

Rural Alaska and the indigenous people have important stories to tell on how the changing climate is impacting the traditional ways of life. Developing a series of television segments would foster better understanding of how changes in future climate, both gradual and sudden, can impact communities and individual lives. This can become a catalyst for change in individual behavior. Research into these stories and observations will improve the sharing of traditional knowledge and wisdom while increasing the publics' understanding of climate change and the impacts to the health and culture of rural residents. *Priority: NA. Urgency: Low* as covered by other networks. Distribution to rural Alaska may be a different unmet need. *Action Type: Education/Outreach. Cross-Cutting Topics: All*

**5.2.1.13 Research and develop culturally appropriate curriculums and materials for traditional knowledge and local observations with accuracy of observations**

Cross-cultural understanding of the impacts of climate change will benefit when prepared in culturally appropriate curriculum that recognizes the complimentary role and value of observations and scientific measurements with traditional knowledge. Developing this cross-cultural curriculum may be supported with social scientists who understand the scientific method and native leaders that are seeing the impacts of climate change on their traditional knowledge. Research conducted in developing this material will have a greater likelihood of community

buy-in, cultural acceptance and to be implemented. **Action Type: Education/Outreach. Cross-Cutting Topics: All**

**5.2.1.14 Improve communications between federal scientists and state government agencies (such as the Alaska Departments of Fish and Game, Environmental Conservation, and Natural Resources) on climate science, the potential impacts, and data needs for those agencies concerning climate change.**

State and Federal Science and Resource Agencies and stakeholders have concern that the information is not accurate or all inclusive. This leads to questions on whether decision makers do not make decisions or communities have insufficient information to make an informed decision. Regardless, with the number of working groups that have collaborated for decades there are still challenges in applying research results to public policy and social and cultural impacts. The Governor's sub-cabinet and working groups are an example of an effective method to address this issue. **Action Type: Education/Outreach, Data Management. Cross-Cutting Topics: All**

## Specific Research Needs

Specific research needs identified by the Health & Culture TWG are presented below. They are discussed in more detail in the appendix.

### 5.2.2 Subsistence Research

**5.2.2.1 Decline and migratory shifts of major subsistence species and vegetation can significantly affect a wide range of cultural, community, and economic conditions. The effects of events must be assessed after an assessment is made of existing climate related socio-economic studies.**

Assess socio-economic impacts of existing and emergent climate change events on culture, community wellness, subsistence, and overall economics. Assess socio-economic impacts of existing and emergent climate change events on culture, community wellness, subsistence, and overall economics.

The enculturation process of young hunters and gatherers through experienced adults can be severely disrupted with loss or disappearance of important subsistence species. Migration of wildlife may require extended subsistence trips, increasing costs and risks as well as substitution of expensive store bought foods.

**Action Type: Products, Education/Outreach. Cross-Cutting Topics: NA**

**5.2.2.2 Standardized ADF&G Harvest Surveys.**

This includes considerable social, demographic and economic information in addition to household harvest per species. Harvest surveys need to be accomplished in each of the villages designated with emergency status.

*Action Type: Monitoring, Products, Education/Outreach, Data Management.*  
*Cross-Cutting Topics: Health and Culture, Economic Activities, and Transportation and Land Use*

### 5.2.3 Social Impact Assessment

#### 5.2.3.1 Regional assessments of existing social service infrastructure, staffing, budgets and delivery need to be accomplished at regional level as baseline to plan for increased demand.

Services are changing with the stress on rural communities that are increasing because of many factors, including climate change. Stressors include health, behavioral health, and culture with sustainability. Having accurate assessments based on research results and predictive models will allow decision makers to make plans for meeting these future needs. *Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: NA*

#### 5.2.3.2 Social Impact Assessments need to be conducted at regional and community level to provide information for Section III of the NEPA process, description of the affected environment.

Gathering social impact assessment information will be needed to complete impact assessments and provide preferred alternatives. By assessing the cultural impacts in an analytical manner, thorough documentation of the questions, responses and recommendations will be available to support the preferred alternatives. *Action Type: Modeling, Products. Cross-Cutting Topics: NA*

#### 5.2.3.3 Detailed interviews and oral histories need to be conducted to provide narrative information needed to assess the impacts of climate change and the potential impacts of different forms of relocation.

As stressors associated with climate change impact health and culture of rural communities and indigenous people, risks to cultures and oral histories exist. Insuring comprehensive collection and archiving will preserve heritage. This is critical as heritage is being lost with aging and passing of elders. These interviews and oral histories need to be placed in a comprehensive library and archive. *Action Type: Products, Education/Outreach. Cross-Cutting Topics: NA*

### 5.2.4 Bio-Environmental Impact Assessment

#### 5.2.4.1 Assess ADEC watershed contamination protection laws and source water protection program. Assess effectiveness of current monitoring and surveillance programs to identify and control new pathogens or increased contaminant infiltration/runoff from.

Increased temperatures, changing precipitation patterns, flooding, melting permafrost, and other climate change-related risks could alter the geographic range and incidence of a wide range of infectious diseases and can result in



contamination of food and water sources. A research program that assesses the effectiveness of current monitoring and surveillance programs, while identifying improvements given the uniqueness of changing climate and geographic ranges, is needed. **Action Type: NA. Cross-Cutting Topics: NA**

**5.2.4.2 Assess sanitation and solid waste disposal infrastructure and practices at risk from flooding, melting permafrost, and other risks, or that is otherwise subject to changed conditions that significantly reduce performance in environmental health protection.**

Increased temperatures, changing precipitation patterns, flooding, melting permafrost, and other climate change-related risks could compromise sanitation and solid waste disposal infrastructure and render current practices ineffective. Research is needed in assessing the risk to existing facilities and identifying options for adapting the facility in the face of risks. Modeling of potential loss to erosion or flooding and associated risks to environmental health is needed. **Action Type: NA. Cross-Cutting Topics: NA**

**5.2.4.3 Work to quantify the climate warming impact from the potential release of methane hydrates in the Arctic due to warmer sea temperatures.**

Study climate warming and methane hydrate deposits. **Action Type: NA. Cross-Cutting Topics: NA**

**5.2.4.4 Study the potential increase in bioavailability of persistent organic and transboundary pollutants, including pesticides, mercury, perfluorochemicals and flame retardants, which may be released from melting ice and snow and thawing soil as a result of climate warming in the arctic.**

Transport of pollutants and toxins with changes in atmospheric flows and oceanographic currents are impacting Alaska. Evaluate the potential health impacts on humans, ecosystems from toxins, persistent organic chemicals and other pollutants, including their behavior in the food web. Develop projections as to whether these impacts and release rates can be expected to increase and to what degree in the future. Conduct the research in determining the extent and risk to health in the Arctic. **Action Type: Monitoring. Cross-Cutting Topics: NA**

**5.2.4.5 Study the interaction of increased UV exposure in the arctic on humans, animals and vegetation in conjunction with projected climate changes.**

Climate change can change UV exposure that may affect human health and change plant and animal distribution. Research to study climate warming and Ultra-violet radiation, including monitoring plans will help to document the risks associated with the increased UV exposure. Research should include understanding the impact on people, flora and fauna, and traditional ways of life and culture. **Action Type: NA. Cross-Cutting Topics: NA**

## 5.2.5 Cultural Resources Impacts

- 5.2.5.1 1) In cooperation with appropriate entities, complete an assessment of archaeological sites most at risk, and develop a plan for their protection or recovery. 2) Complete a statewide assessment of and response to the gravesites most at risk.**

Research to improve the understanding of the potential cultural impacts of climate change on indigenous people must consider archeological sites. Increased temperatures, changing precipitation patterns, flooding, melting permafrost, and other climate change-related risks will affect the stability of archeological sites and gravesites, requiring plans for protection or recovery. The magnitude of the problem will depend on a complete statewide assessment and a mitigation plan to reduce the loss and allow relocation. Developing a confidential but interactive data base should stem from this research. **Action Type: NA. Cross-Cutting Topics: NA**

## 5.2.6 Community Capacity Assessment

- 5.2.6.1 1) Identify effective cooperative mechanisms to support rural communities in dealing with multiple rules and requirements. 2) In partnership with local communities, conduct an assessment of the capacity of communities to design and implement programs.**

Increased temperatures, changing precipitation patterns, flooding, melting permafrost, and other climate change-related risks will present a wide range of challenges to rural communities that will require them to deal with multiple state and federal agencies, with overlapping and sometimes conflicting rules and regulations. Researching socio-economic and socio-cultural methods to equip rural communities in gaining assistance in designing and implementing programs that adapt a community is needed. **Action Type: NA. Cross-Cutting Topics: NA**

## 5.3 Natural Systems (NS) TWG

The Natural Systems Technical Working Group (TWG) has developed a catalog of adaptation options related to the expected effects of climate change on Alaska's natural systems. This section presents research needs associated with the work group's recommendations on the relevant actions the State of Alaska could take to adapt to changes in Alaska's natural systems due to climate change. The research needs work group looked at adaptation options in the following areas: Fisheries, Wildland Fire, Freshwater Resources, Invasive Species and Disease, Fish and Wildlife Management, Forestry and Wood Biomass, Sustainable Agriculture, and Natural Hazards.

## **TWG Recommendations**

The TWG forwarded the following adaptation policy options for consideration by the Climate Change Sub-Cabinet:

- NS-1. Incorporate climate change into **fisheries** management and assist fishing communities and users in adaptation.
- NS-2. Review and modify Alaska's **wildland fire** policy and programs.
- NS-3. Address the effects of climate change on **Alaska's freshwater resources** through adaptive management, supported by improved hydrologic data.
- NS-4. Reduce introduction and spread of **invasive species** in the context of climate change.
- NS-5. Prepare for **adaptive management of fish and wildlife**.
- NS-6. Develop capacity in new **forestry and wood biomass** opportunities.
- NS-7. Support **local sustainable agriculture** in Alaska.

## **RNWG Recommendations**

The RNWG recommended the following additional policy option relative to Natural Systems:

- NS-8. Reduce risks to health, safety and property from **natural hazards** resulting from climate change.

## **Research Needs**

### **5.3.1 Overarching Research Needs**

Overarching research needs for Natural Systems TWG activities include:

#### **5.3.1.1 Develop better hydrology data and models statewide.**

Trend data and global climate models indicate a warmer and sometimes wetter climate for Alaska in the future. Planning for river navigation, flood hazard estimation, and cost-efficient engineering of public roads, culverts, bridges, water, and wastewater systems require accurate estimation of water flow volume and seasonality. Historic data and existing statewide coverage are inadequate for present and future needs. **Action Type: Data Management, Modeling, Monitoring. Cross-Cutting Topics: Overarching**

#### **5.3.1.2 Identify permafrost thaw hazards and incorporate into engineering guidelines.**

Many of the scenario models used in IPCC reports suggest that widespread permafrost thaw will occur across the Northern Hemisphere in this century. Cracking roads and subsiding building foundations are common in some areas where permafrost thaw is occurring. Landslides and mudflows are also occurring on thawing wet hill slopes, sometimes blocking roads, rivers, and degrading fish habitats. Engineers, builders, and planners need accurate maps and forecasts for

planning. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: Overarching**

**5.3.1.3 Identify and research laws, policies, and regulations that could be modified to better support adaptation.**

Many of the laws, policies, and regulations that direct management of public and private lands and waters are premised on stable climates, or at least on the ability to envision future conditions (e.g., ANILCA, ESA, CFR, CZMA). What will be the standard of successful resource management in a changing future? Can state and federal agencies preserve the unique and special values that are identified in legislation in the face of climate change? How will they develop adaptation strategies for fish, animals and plants when their natural climate zones move beyond management units, state and national borders? How can access to subsistence resources be ensured in light of changing resource availability, sedentary human settlement patterns, and the mix of agency rules and regulations? **Action Type: Products. Cross-Cutting Topics: Overarching**

**5.3.1.4 Implement local climate change scenario planning workshops in communities across Alaska (coastal, arctic, interior, etc.).**

Alaskan's are receiving conflicting, sometimes sensational and frightening information about climate change from many sources. While environmental change has taken place in Alaska for a long time, much of the state's permanent development occurred before future climate change was given serious consideration. Recent trends and forecasts have made it increasingly apparent that future climate change needs to be factored into community planning. However, few communities really understand what additional changes to expect in their area, or how fast to expect them. As heard at the ACTEM climate change session, communities need updated mapping, photographs, and projections of environmental changes to be able to effectively plan for their adaptation to climate change. **Action Type: Modeling, Products, Education/Outreach, Data Management. Cross-Cutting Topics: Overarching**

**5.3.1.5 Identify and assess health and safety hazards resulting from climate change**

Research is needed to identify risks and opportunities for early warning, avoidance, and hazard mitigation. Rapid climate change affects fire regimes and forest fuel hazards, physical hazards (glacial outbursts and river flooding, surging glaciers, avalanches, landslides, ground failures, solifluction, erosion, inundation, subsidence), invasive species (plants, animals, pests and diseases), species habitat loss and fragmentation, and vulnerabilities to spread of contaminants resulting from persistent organic pollutants (POPS) and permafrost thaw. **Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: Overarching**

**5.3.1.6 Coordinate data integration.**

Decisions are being made without benefit of available data and redundant research activities are started for lack of access to existing data. Better access to existing data would be a cost-effective measure to provide more information for better decision making. *Action Type: Data Management. Cross-Cutting Topics: Overarching*

**5.3.1.7 Research changes to vital ecosystem services.**

The cascading effects of large scale environmental change can affect critically important natural services and economic resources, such as water supply, air quality, ocean fisheries, etc. For example, large scale changes to boreal forest are expected, with uncertain effects to other factors. Information about potential “tipping points” could help to avoid situations where vital ecosystem services are no longer being provided (e.g. wildlife and fisheries population crashes). *Action Type: Modeling. Cross-Cutting Topics: Overarching*

**5.3.1.8 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.**

There are highly important specific early needs to facilitate other data gathering efforts. For example, accurately represented coastal land elevations are needed for modeling how sea level rise will affect low lying coastal areas. *Action Type: Products, Data Management. Cross-Cutting Topics: Overarching*

**5.3.1.9 Conduct coastal mapping and shoreline characterization.**

Baseline data is needed to enable coastal impact forecasting, scenario planning for sea level rise and coastal erosion, monitoring, trend analysis, and spill response following shipping accidents, which are expected to increase as sea ice diminishes in the Northwest Passage. *Action Type: Products, Data Management. Cross-Cutting Topics: Overarching*

**5.3.1.10 Assess, model, and monitor coastal impacts of changes to sea level and ice.**

Coastal erosion is increasing with reduced sea ice cover and thawing permafrost. Rapid erosion is exposing buried infrastructure, undercutting road and building foundations, and destroying natural and cultural resources. *Action Type: Modeling, Products, Data Management, Monitoring. Cross-Cutting Topics: Overarching*

**5.3.1.11 Develop and refine down-scaled climate models.**

Global Climate Model data is too coarse to inform communities and local resource managers about probable changes at local levels. *Action Type: Modeling, Products, Education/Outreach, Data Management. Cross-Cutting Topics: Overarching*

**5.3.1.12 Coordinate climate and ecosystem monitoring programs among agencies, organizations, and institutions.**

Long-term datasets with reliable indicators and across large geographic areas (regional and continental scale) are essential to determine climate and resource condition trends. *Long-term. Action Type: Products, Data Management, Monitoring. Cross-Cutting Topics: Overarching*

**5.3.1.13 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.**

Improved monitoring of key climate change indicators relevant to Alaska will allow for tracking of climate change effects and will contribute data to modeling and assessments. Monitoring of locally-appropriate indicators and development of thresholds is needed to determine when change is occurring to rapidly for communities to adapt to impacts related to climate change. This information is needed to inform assessments of societal impacts and support planning and adaptation. *Action Type: Modeling, Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: Overarching*

**5.3.1.14 Conduct research on protecting community water supplies and instream flows.**

Freshwater runoff from snow and ice melt is a major source of drinking water for communities. Adequacy of future supplies cannot be assumed with climate change. *Action Type: Modeling, Products. Cross-Cutting Topics: Overarching.*

**5.3.1.15 Expand research and monitoring of contaminants deposition and bioavailability under changing climate.**

Contaminants can affect health and survival of fish, wildlife, and people. Results from WACAP and other studies indicate higher than expected levels of contaminants even in remote areas. *Action Type: Modeling, Products, Education/Outreach, Monitoring. Cross-Cutting Topics: Overarching*

**5.3.1.16 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.**

Understanding changes in landcover types are critical to assessments related to fire, forestry, wildlife, fisheries, etc. GIS and maps are basic tools needed for many analyses. *Action Type: Products, Data Management. Cross-Cutting Topics: Overarching*

#### **5.3.1.17 Assess communications strategies for climate change information.**

Poorly communicated information about climate change can cause more harm than good. *Action Type: Education/Outreach. Cross-Cutting Topics: Overarching*

### **Specific Research Needs**

Specific research needs are discussed in more detail in the appendix.

## **5.3.2 Fisheries**

#### **5.3.2.1 Synthesize current information about climate change impacts on fisheries and assess its reliability and degree of uncertainty.**

Conduct fisheries ecological modeling. *Action Type: Modeling, Products, Data Management. Cross-Cutting Topics: NA*

#### **5.3.2.2 Conduct Arctic Ocean fisheries assessments.**

Fisheries population shifts are occurring due to ecological change, and ship access is increasing with reduced sea ice. Commercial fishing in new areas would have uncertain effects to previously unaffected populations. *Action Type: Modeling, Products, Monitoring. Cross-Cutting Topics: NA*

#### **5.3.2.3 Increase real-time monitoring and forecasts of physical ocean conditions (winds, waves, sea ice, currents, temperature, salinity, pH, etc.).**

Improved monitoring and forecasting of changing ocean conditions will inform modeling and forecasting of related biotic changes, as well as inform marine-based human uses. Physical data is needed to predict and explain biological responses. Information is needed about impacts of freshwater from glacial melt on marine ecosystems, to improve understanding of effects of climate change on marine ecosystems. Water temperature increases are correlated with oceanic regime changes and with locally reduced salmon returns and increased fish disease (e.g., *Ichthyophonus* in Yukon River salmon). Ocean acidification of the magnitude that has been occurring is expected to have significant impacts to food webs, and certain species (e.g. corals, shellfish). *Action Type: Education/Outreach, Data Management, Monitoring. Cross-Cutting Topics: NA*

#### **5.3.2.4 Research fisheries policy considerations.**

Research what other countries, U.S. federal agencies and other states are doing to incorporate climate change considerations into commercial fishing policies, management, and other adaptations. Assess what is appropriate to Alaska conditions. *Action Type: Products. Cross-Cutting Topics: NA*

**5.3.2.5 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.**

Broad scale changes in fisheries species abundance and distribution are expected. Changing stream and lake biochemistry may drive freshwater ecosystem change and change the abundance and distribution of species of commercial or subsistence importance (as well as other effects.) Monitoring is essential to inform policy, management, and users' decisions. Data will support modeling and forecasting. The Anadromous Waters Catalog is the key tool for documenting freshwaters that are important to anadromous fish and to provide protection for these habitats. *Action Type: Monitoring. Cross-Cutting Topics: NA*

**5.3.2.6 Consider need for protected fish conservation areas.**

Evaluate tools for fish species conservation. Expanding fisheries pressure can deplete target and by-catch populations and degrade habitats. Reduced sea ice increases the likelihood of increased fishing pressure in Arctic waters. *Action Type: Products. Cross-Cutting Topics: NA*

### **5.3.3 Wildland Fire**

**5.3.3.1 Expand modeling of wildland fire, fuel, and smoke.**

Fire hazards are expected to increase with rising air temperature, longer growing seasons, and increased soil dryness. Dense and long-lasting smoke from wildland fires can result in severe acute and chronic health impacts in affected communities. *Action Type: Modeling. Cross-Cutting Topics: NA*

**5.3.3.2 Review and coordinate wildland fire policies with Canadian counterparts.**

Determine efficacy and ecological effects of different fire management policies. Current wildland fire policy is not Full Suppression. Research would inform policy makers about potential positive and negative effects to wildlife habitat of allowing wildland fires to burn. *Action Type: Modeling, Products. Cross-Cutting Topics: NA*

**5.3.3.3 Research Tundra fire effects and develop measures to reduce impacts.**

Tundra fires are expected to increase as shrubs move into tundra and as soils dry from climate warming. Remote communities have limited fire fighting capacity. *Action Type: Products, Education/Outreach. Cross-Cutting Topics: Health and Culture*

### **5.3.4 Invasive Species**

**5.3.4.1 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.**

Established terrestrial, aquatic, and marine species are shifting north into Alaska, while other species are also arriving from other seas and continents. Some new arrivals will compete with current species or carry parasites and diseases previously not present in Alaska. **Action Type: Modeling, Products, Education/Outreach, Monitoring. Cross-Cutting Topics: Forestry, Agriculture & Waste, Health & Culture**

**5.3.4.2 Provide effective monitoring, forecasting and response to marine invasive species.**

The number and distribution of invasive species is expanding in Alaska. Invasive species frequently out-compete valued native species and cause severe economic and ecological damage. Invasive marine species can arrive in ballast water, ship hulls and gear, through aquaculture/mariculture releases, and as a result of changing ocean conditions and migration patterns. **Action Type: Education/Outreach, Data Management, Modeling, Monitoring. Cross-Cutting Topics: NA**

**5.3.5 Fish and Wildlife**

**5.3.5.1 Improve wildlife and fisheries populations and harvest rate data and access.**

Alaska's terrestrial, aquatic and marine ecosystems are changing, as are the natural habitats required by wildlife and fishery species. Scientists expect rapid change in some areas as trees and shrubs expand into tundra, as fires reduce the size and extent of coniferous forests, and as permafrost thawing and thermokarst formation change the distribution and size of wetlands. Alaska's rural population, tourism industry, and many businesses depend on healthy wildlife and fish populations for food and income. Accurate monitoring data and forecasts are needed to inform decision makers about resource management needs and options, including changes to laws, policies, and regulations. **Action Type: Modeling, Data Management, Monitoring. Cross-Cutting Topics: Health & Culture, Economic Activities**

**5.3.5.2 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.**

Climate change will have cascading effects on multiple physical, biological, social, and cultural resources. However, the scope and scale of those effects is largely undetermined. **Action Type: Modeling, Products. Cross-Cutting Topics: NA**

#### **5.3.5.3 Evaluate and improve methods for caribou population enumeration.**

Subsistence communities need accurate information to adjust harvest patterns to changing wildlife abundance. Some herds are in decline and others may be. The accuracy and timeliness of caribou monitoring programs has been questioned by stakeholders and cooperators. *Action Type: Modeling, Products, Data Management, Monitoring. Cross-Cutting Topics: NA*

#### **5.3.5.4 Assess disjuncts between calendar dates for legal harvest, and actual biological behavior of species.**

For example, moose hunters are concerned that legal harvest dates don't always correspond with available harvest opportunities. Managers are concerned that shifting a hunt into the rut period (when bulls are preoccupied with breeding) can increase hunting success, which could be problematic for low-density populations or those with a low bull: cow ratio. Improved methods for moose population enumeration are needed. *Action Type: Products, Monitoring. Cross-Cutting Topics: NA*

#### **5.3.5.5 Identify how "sentinel" ecosystems are changing.**

Continued monitoring in those areas where there are already long-term records could provide valuable trend information. *Action Type: Monitoring. Cross-Cutting Topics: NA*

### **5.3.6 Forestry and Wood Biomass**

#### **5.3.6.1 Research and monitor forest response after disturbance.**

Research ecological "tipping points." Trees are moving into higher altitudes and higher latitudes as climate warms. Many common species are experiencing severe and recurring pest outbreaks (e.g., bark beetles, budworms, leaf miners) related to climate change (increased temperatures and transpiration, reduced soil moisture). Fire effects are increasing as flammable shrubs and trees expand into tundra, and as fire frequency increases in boreal forests. However, the full scope and trends has not been determined. *Action Type: Modeling, Products, Data Management, Monitoring. Cross-Cutting Topics: NA*

#### **5.3.6.2 Assess efficacy, economics, and ecological effects of salvage logging to produce timber and wood biomass fuels from fire- and insect-killed trees.**

Climate change-related warming and drying is likely to result in more insect and fire-killed timber and biomass. *Action Type: Products, Education/Outreach. Cross-Cutting Topics: NA*

**5.3.6.3 Test various wood burning appliances and their air quality emissions in an arctic environment.**

Increased use of wood and woody biomass as a “carbon neutral” heating fuel has potential to affect local air quality and resident health. **Action Type: Products, Education/Outreach. Cross-Cutting Topics: Health and Culture**

**5.3.6.4 Research net contributions of Alaska’s natural areas to GHG release and sequestration.**

Recent climate change is largely driven by greenhouse gas (GHG) levels. The effectiveness of cap and trade measures will also be affected by natural carbon sequestration and emissions. Understanding the relative contribution of sources of GHG compared to other human and natural sources is essential. Accurate modeling is critical for effective mitigation of atmospheric greenhouse gas emissions. Carbon emissions cap and trade systems are now being implemented to reduce global emissions of greenhouse gases. These systems are based on models of gas emissions and gas sinks. Current models cannot accurately determine whether Alaska’s wild lands will sequester more carbon in vegetation than they release through wildland fires, oxidation of thawed organic permafrost, methane hydrates, etc. **Action Type: Modeling, Products. Cross-Cutting Topics: Mitigation**

## **5.3.7 Sustainable Agriculture**

**5.3.7.1 Research agricultural products and practices suitable for changing conditions.**

Research new agricultural product opportunities, technologies and best practices, including locally produced fertilizer and waste nutrient utilization (e.g., fish carcasses/processing waste), in order to prepare to capitalize on opportunities to expand sustainable agriculture in Alaska. Climate change may provide new opportunities in sustainable agriculture that may be of increased importance to food security as access to other food sources changes due to lost fish and wildlife harvest opportunities or increased costs for shipped foods. **Action Type: Modeling, Products, Education/Outreach. Cross-Cutting Topics: NA**

## **5.3.8 Natural Hazards**

**5.3.8.1 Assess effects of climate on safe access for hunting, fishing and other subsistence activities.**

Access to subsistence hunting and fishing on land and water is critical for survival in many areas. Accurate forecasting is important to enhance safety of travel in road-less areas. Changes in freeze-up and thaw timing and conditions continue to affect subsistence harvest opportunities and uses through inaccessibility and/or increased access hazards. Low river water may also preclude access. Changes in

safe access may require consideration of alternative access means, changes in season timing, or other adaptation. Access by traditional means may also damage resources when conditions change (e.g. ORVs or snow machines on wet thawed ground). **Action Type: Modeling, Products, Education/Outreach, Monitoring.**  
**Cross-Cutting Topics: Health and Culture**

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

Engineers are sometimes using out-of-date environmental information in designing new facilities in Alaska, which may result in premature obsolescence or failure. **Action Type: Products. Cross-Cutting Topics: Transportation and Land Use, Public Infrastructure**

### **5.4 Public Infrastructure (PI) TWG**

The Public Infrastructure TWG identified and evaluated options and opportunities for the State of Alaska to enhance the resiliency and adaptive capacity of Alaska’s public infrastructure to the current and potential future effects of climate change. They defined public infrastructure as the essential facilities and utilities under public, cooperative, or private ownership that deliver goods and services to Alaska’s communities.

#### **TWG Recommendations**

The Public Infrastructure TWG recommends that State government adopt a systems-based vision for sustainable infrastructure that supports communities in an uncertain environment. This systems approach means shifting infrastructure planning and investment decision-making from a competitive and disconnected project-based orientation to a holistic, long-term, common outcome-based orientation. The TWG policy recommendations are:

- PI-1. Create a statewide system for key data collection, analysis, monitoring, and access.
- PI-2. Promote “No Regrets” Improvements
- PI-3. Build to last. Build resiliency into Alaska’s public infrastructure.

#### **RNWG Recommendations**

To these policy options the following additions are recommended:

- PI-4. Include funding for long-term monitoring of infrastructure in operating budget.
- PI-5. Develop and incorporate best practices for energy use reduction and greenhouse gas reduction into state agency policies and procedures.

### **Research Needs**

#### **5.4.1 Overarching Research Needs**

Overarching research needs for Public Infrastructure TWG activities include:

**5.4.1.1 Collect climate data and develop methodologies and capacity to enhance and increase the resolution of climate forecasting models.**

Downscaled climate forecasts are needed so that Federal, state, and community planners & decision makers can establish: 1) time horizons within which they will need to address infrastructure fortification or relocation; 2) locations and designs of new infrastructure that accommodate these conditions; and 3) location-specific conditions that new infrastructure must be designed to accommodate. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring.**  
**Cross-Cutting Topics: NA**

**5.4.1.2 Develop and deploy effective mechanism(s) to increase the availability and maximize the exchange of authoritative, defensible, and timely information to support analysis and decision-making on issues of climate change adaptation & mitigation, sustainability, and resiliency.**

Climate analysis information delivery and availability is decentralized and uncoordinated, creating inefficiency, duplication of effort, wasted money, and difficulty in locating information of consistent and acceptable quality for a variety of purposes. **Action Type: Products, Education/Outreach, Data Management.**  
**Cross-Cutting Topics: NA**

**5.4.1.3 Develop a mechanism to systematically identify, collect, and analyze the data that it needs to economically plan, develop, and manage its public infrastructure in a sustainable manner.**

The state's current project-based focus on infrastructure development discourages investment in the systematic collection and evaluation of long-term post-construction performance data after construction. Infrastructure performance monitoring and modeling is necessary to effectively evaluate if and how infrastructure might be developed more sustainably in Alaska. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring.**  
**Cross-Cutting Topics: NA**

## **5.4.2 Specific Research Needs**

**5.4.2.1 Analyze, develop, and update existing engineering and building codes and construction techniques for new infrastructure and structures in vulnerable areas.**

Current designs likely do not incorporate the real risks and variability associated with climate change in Alaska. Consequently infrastructure may fail prematurely or require unnecessary expense to build and maintain, resulting in uneconomical and unacceptable risks to Alaskan communities. **Action Type: Modeling, Products, Education/Outreach, Data Management, Monitoring.**  
**Cross-Cutting Topics: Energy Supply and Demand, Transportation & Land Use**

**5.4.2.2 Establish an integrated baseline inventory on the location and condition of public infrastructure. Collect, assess and monitor data needed to develop sustainable solutions to adapt public infrastructure to the effects of a changing climate.**

A complete inventory of public infrastructure (that is either now, or likely to be, at risk from the effects & hazards due to climate change) is needed in order to systematically identify public infrastructure vulnerability. Data that does exist is owned by several agencies and not effectively integrated and shared amongst. Inefficient duplication of effort is likely given the functionally separate organization and operations of State agencies. **Action Type: Data Management, Monitoring. Cross-Cutting Topics: Energy Supply and Demand, Transportation & Land Use**

**5.4.2.3 Identify, analyze, and use national and international research results and products as a basis for developing solutions and expanding best management practices in AK.**

Employees of Alaska State agencies are not consistently clear about the role their agencies play in developing and supporting sustainable and resilient infrastructure. Performance measures of state agencies do not consistently recognize a systems approach and the value of sustainability and resiliency for state investments. State leaders have a tendency to manage public infrastructure funding decisions as expenses rather than investments. **Action Type: Products, Education/Outreach. Cross-Cutting Topics: Energy Supply and Demand, Transportation & Land Use**

## 6 Glossary of Terms

ACCAP	Alaska Center for Climate Assessment & Policy
ACCS	Alaska Climate Change Strategy
ADCCED	Alaska Department of Commerce, Community, & Economic Development
ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ADOT&PF	Alaska Department of Transportation & Public Facilities
AEDIS	Alaska Engineering Design Information System
AFS	Alaska Fire Service
AGDC	Alaska Geospatial Data Committee
ANHP	Alaska Natural Heritage Program
AOOS	Alaska Ocean Observing System
ASG MAP	Alaska Sea Grant Marine Advisory Program
BLM	US Bureau of Land Management
CCER	Climate Change Executive Roundtable
CCREL	US Army Corps of Engineers-Cold Regions Research and Engineering Laboratory
CNIPM	Alaska Committee for Noxious and Invasive Plants Management
DEM	Digital Elevation Model
DOD	US Department of Defense
DOE	US Department of Energy
DOI	US Department of Interior
EVOSTC	Exxon Valdez Oil Spill Trustee Council
FS	US Forest Service
FSP	Federal Subsistence Program
FWS	US Fish and Wildlife Service
GHG	Greenhouse gas
GINA	Geographic Information Network of Alaska
ISER	University of Alaska Institute of Social and Economic Research
JFSP	Joint Fire Science Program
NASA	National Aeronautics and Space Administration

NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPRB	North Pacific Research Board
NPS	National Park Service
NRCS	Natural Resource Conservation Service
NSSI	North Slope Science Initiative
NWS	National Weather Service
PRISM	Parameter-elevation Regressions on Independent Slopes Model
SNAP	Scenarios Network for Alaska Planning
State	State of Alaska
UAA	University of Alaska Anchorage
UAF	University of Alaska Fairbanks
USCG	US Coast Guard
USGS	US Geological Survey
WACH	Western Arctic Caribou Herd



## 7 Research Needs Work Group Composition

<b>Mitigation (M)</b>	<b>Adaptation (A)</b>	<b>Name</b>	<b>Organization</b>	<b>Focus</b>
	A	Amy Holman	NOAA	Climate
	A	Bill Streever	BP	Wildlife/O&G impacts
	A	Bob Pawlowski	Denali Commission	Rural AK sustainability
	M	Bob Swenson	DNR	Geologically hosted resources
	A	Bob Winfree	NPS	Park Service
	A, M	Buck Sharpton	UAF	Cross cutting
	M	Chris Maisch	DNR	Forestry/Biological sequestration
	A	Clint Adler	ADOT& PF	Co-Chair, Transportation
	M	Clint Farr	ADEC	Emissions Inventory
	A	Craig Fleener	ADF&G	Subsistence/Wildlife
	A	Dan White	UAF Institute of Northern Engineering	Engineering/Hydro
	M	Doug Vincent-Lang	ADF&G	Co-Chair, Fish and Wildlife
	M	Jackie Holzman	FAA	Aviation
	A	Jon Zufelt	Corps of Engineers	Infrastructure
		Kristie L. Ebi	ESS, LLC.	
	A	Molly McCammon	AOOS	Oceanic/Atmospheric
	M	Peter Crimp	AEA	Renewable energy



## 8 Acknowledgements

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# Appendix A

## Technical Work Group Reports

Full, detailed recommendation reports by RNWG ordered by TWG.



## TWG: Energy Supply and Demand

### 4.2.1.1

**Carbon sequestration research is needed to better understand the state's options for storing carbon in geologic formations. This research involves field investigation of likely sites as well as laboratory testing of formations that have the potential to fix the carbon (e.g., in carbonates).**

Unique Identifier: 66

Overarching Need

#### Why is this an issue?

Alaska has a major coal resource. New coal power plants or coal to liquids processes will likely either require carbon sequestration or be negatively impacted by carbon caps or taxes. In order to prepare the state for both managing the carbon dioxide it produces currently and for permitting of new carbon dioxide producing facilities, sequestration options must be available.

#### Describe the scope of the research need:

The scope involves field investigations of suitable sites, mapping, and equilibrium/reservoir of good candidates for sequestration. This likely covers the entire state, though areas of opportunity would be co-located with carbon producing units.

#### Policy option or recommendation:

This falls under the combined ESD Policy Options 7,8,9.

Recommended action: Direct and fund state agencies (e.g., UA, ADNR) to investigate the potential for CO<sub>2</sub> sequestration in geologic formations.

#### What research is being done/known?

No field research has been conducted in Alaska with the exception of the EOR, which is only one form of geologic sequestration.

#### What are the gaps in research?

Aside from spent oil and gas reservoirs, we have major gaps in our understanding of the potential sequestration formations, the long term viability of the formations, chemical reactions in the reservoir, and the costs associated with use of the formations.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Oil and Gas

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

ADNR, UA

## TWG: Energy Supply and Demand

### 4.2.1.2

Research should be conducted into value added carbon capture technologies such as carbon capture and use in greenhouses for food and energy production, carbon incorporation into high-tech products, such as carbon fiber or H2 storage, enhanced oil recovery, and carbon addition to H2 for fuels production. Many other options may be available. Research is needed to determine which opportunities hold the greatest promise for Alaska.

Unique Identifier: 65

Overarching Need

#### Why is this an issue?

In order to comply with future carbon caps, trading, taxation, and carbon dioxide reduction for mitigation purposes, the state needs options for carbon dioxide management. Beneficial use makes the most sense if reasonable options are available.

#### Describe the scope of the research need:

The research need ranges from basic research (e.g., carbon fibers), to testing and demonstration of greenhouse applications (e.g., algae for biofuels). Some of the opportunities, such as carbon capture in greenhouses might require applied research in year-round, low energy applications (e.g., LEDs).

#### Policy option or recommendation:

This falls under the combined ESD Policy Options 7,8,9.

Recommended action: Direct and fund state agencies (e.g., UA, ADNR, Dept of Commerce) to investigate the potential for CO2 capture and management value-added products and technologies.

#### What research is being done/known?

Some research is presently being conducted in Alaska, though this research does not presently focus on fuels production. Much of what is being done is done through the University of Alaska or smaller private greenhouses such as that at the Chena Hot Springs Resort. The Office of Electronic Miniaturization at the University of Alaska is currently doing work on carbon fibers.

The Alaska Center for Energy and Power is working with the Fairbanks North Star Borough to develop a Food and Energy Research Station. This effort will include carbon capture in greenhouses producing both fuels and food for the region.

#### What are the gaps in research?

Gaps are different for the breadth of beneficial uses. It is not known how much carbon could be captured in greenhouses designed for high CO2 processing.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Oil and Gas

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

The University of Alaska (particularly the Alaska Center for Energy and Power, the Institute for Social and Economic Research, and the Agriculture and Forestry Experiment Station), private industry, state agencies



## TWG: Energy Supply and Demand

### 4.2.1.3

**Research is needed to improve efficiency from improved control and operation practices of existing generation capacity (e.g., diesel). This includes the management of hybrid systems which typically are very complicated from a management and control standpoint.**

Unique Identifier: 64

Overarching Need

#### Why is this an issue?

Carbon emissions can be reduced by increasing the efficiency of carbon producing processes such as diesel power generation and hybrid power systems. Here the goal is not to improve the efficiency of the diesel engine itself, but to introduce control strategies that would reduce the net carbon emissions from the diesel power plant without a reduction in supply.

#### Describe the scope of the research need:

Research into diesel and diesel/hybrid systems could be accomplished in a diesel efficiency test bed. In the testbed, technologies and control strategies could be tested with the aim of more efficient operation, saving money and carbon.

#### Policy option or recommendation:

This falls under the combined ESD Policy Options 7,8,9.

Recommended action: Direct and fund state agencies (e.g., UA, ADNR, Dept of Commerce) to establish a diesel test-bed.

#### What research is being done/known?

A collaboration to establish a diesel efficiency testbed has been proposed by the Alaska Center for Energy Power at the University of Alaska and the Alaska Energy Authority as part of the University's FY 10 capital budget.

A good deal of basic and applied research has been done on components to diesel power systems, such as the engine itself, but very little has been done to manage the complex hybrid systems so that they truly lead to efficiencies.

#### What are the gaps in research?

There is presently not test bed in existence for testing alternatives relevant to Alaska.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

UA (Alaska Center for Energy and Power), Controls companies (e.g., Siemens), other private industry, AEA

## TWG: Energy Supply and Demand

### 4.2.1.4

**Research into the best application and best management of a coal-to-liquids technology as well as carbon capture and beneficial use.**

Unique Identifier: 192

Overarching Need

**Why is this an issue?**

Research on the use of coal in the state of Alaska is needed to most effectively develop an abundant energy rich resource while achieving goals for mitigating climate change.

**Describe the scope of the research need:**

The scope ranges from laboratory testing to testing of field demonstrations.

**Policy option or recommendation:**

The state should support research, development and testing into alternatives for coal use coupled with carbon management.

**What research is being done/known?**

Research is being conducted in a variety of areas with Coal, but there is very little funding currently available.

**What are the gaps in research?**

The major research gap is how best to use the coal resource while still mitigating climate change.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Energy Supply and Demand

### 4.2.2.1

**A resource assessment as needed, in addition to research and testing of low temperature power generation designs for power and heat, mineral recovery from geothermal brines, and ground source heat pumps. Additionally, research into uses for power at or close to geothermal prospects should be conducted. Such uses could include value added mineral refining, timber processing, or greenhouse food/energy production.**

Unique Identifier: 63

Overarching Need

#### Why is this an issue?

Many locations in the state could be good candidates for inexpensive geothermal power. The areal distribution and depth of the geothermal resource is unknown for Alaska except a few isolated locations. Without a basic understanding of the geothermal potential, there is little chance that developers will be willing to invest in a geothermal prospect. Exploration often accounts for ¼ to ½ of the cost of a geothermal power development project.

#### Describe the scope of the research need:

A statewide geothermal drilling program is needed. This program can start at known areas of high heat flow in Alaska. Coupled with the drilling program, applied research should be conducted on the extraction of minerals from brines and the extraction of heat and power from low temperature geothermal discoveries.

#### Policy option or recommendation:

This falls under the combined ESD Policy Options 7,8,9.

The state should fund a geothermal resource assessment that could be conducted through a partnership of state agencies, industry and the University.

#### What research is being done/known?

There are a few private companies or individuals who are exploring or exploiting isolated geothermal prospects. Aside from the known developments, little information exists as to the state's geothermal potential outside of hot water surface expressions.

#### What are the gaps in research?

The geothermal potential of the state is unknown. It is also not known to what extent low temperature prospects can be used to provide heat or power.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

ADNR, USGS, AEA, UA (Alaska Center for Energy and Power, Institute for Social and Economic Research, Geophysical Institute).

## TWG: Energy Supply and Demand

### 4.2.3.1

To make hydropower an effective and efficient power alternative, research is needed into technologies for fuel switching (e.g., from gas to electric heat), pumped storage and integration, reducing adverse intake icing conditions, and integration schemes for incorporating small-scale hydro power in village settings where other generating technologies are being used.

Unique Identifier: 61

Overarching Need

#### Why is this an issue?

Hydropower has many different forms and has many issues that determine its ultimate effectiveness as a source of power. If some of these issues were resolved, more hydropower may be accepted in Alaska. Hydropower would be a critical element of the Governor's plan to reach 50% renewable power. In this section hydropower is limited to a water retention and passage through power generating turbines. In-river, tidal, and wave power is discussed in a subsequent section and is referred to as hydrokinetic power.

#### Describe the scope of the research need:

The scope is documented above. There is a range of applied research and testing needs from laboratory and field research to modeling.

#### Policy option or recommendation:

This falls under the combined ESD Policy Options 7,8,9.

The state should fund a hydropower development fund that could support research and testing to support hydropower projects in Alaska.

#### What research is being done/known?

Some research is being done at UA but relatively little, and what is being done would benefit from integration with activities at state and federal agencies.

#### What are the gaps in research?

The main gaps in research on hydropower center around the application of technologies to different environments and different conditions as well as the performance and control.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

ADNR, ADFG, UA (ACEP, others), AEA, NOAA, USGS

## TWG: Energy Supply and Demand

### 4.2.3.2

There is a need for resource assessment, research on the impacts of hydro on fish populations, hydrokinetic device testing, and optimization of hydrokinetic devices for the Alaskan environment (issues such as deployment, anchoring, ice effects, tidal energy capture, etc). Another area of research needed is the application of high pressure water in non-electrical generating applications such as mechanical grinding and processing.

Unique Identifier: 59

Overarching Need

#### Why is this an issue?

Many of Alaska communities are on rivers or along coastlines where hydrokinetic devices could augment power provided by diesel or another source. Unfortunately without some research into the likelihood of success of hydrokinetic devices, very little funding will be dedicated to such prospects.

#### Describe the scope of the research need:

There is a range of applied research and testing needed from laboratory and field testing to modeling. In most cases, the research needs are very applied.

#### Policy option or recommendation:

It is recommended that the state support a hydrokinetic energy test center to serve as a facilities in which state agencies, industries, and citizens can get information on options for hydrokinetic energy production in Alaska.

#### What research is being done/known?

UA-ACEP has formed a hydrokinetic energy test center in Nenana, Alaska. This is coupled integrated with a complementary testing effort led by UAA in Girdwood, Alaska.

#### What are the gaps in research?

The main issues center around the application of the technologies to different environments and different conditions.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

ADNR, ADFG, UA (ACEP, others), AEA

## TWG: Energy Supply and Demand

### 4.2.4.1

**There remain significant issues with wind field modeling, grid integration, power storage, foundations, and de/anti-icing options for wind turbine blades in Alaska that require additional research.**

Unique Identifier: 60

Overarching Need

#### Why is this an issue?

Wind systems are being installed around Alaska. While they are producing power, many are not reducing the use of diesel as much as they could. This is largely a controls, grid integration, and power storage issue. The issue of foundations and de-icing are practical problems increase the cost of wind projects. These issues could be resolved with some applied research and development. Other issues relate to wind field modeling. Wind field models can provide information about variability in power production and are needed before a windfarm can be adequately sited.

#### Describe the scope of the research need:

The need here is for a test center that can test and demonstrate controls and storage technologies or designs before they are implemented in the field.

#### Policy option or recommendation:

This falls under the combined ESD Policy Options 7,8,9.

The state should fund a wind-diesel test center that could serve as a partnership of state agencies, industry and the University.

#### What research is being done/known?

UA-ACEP has formed a Wind-diesel test center to address this. The center is presently building partners in industry and state agencies.

#### What are the gaps in research?

Gaps principally lie in the applied research, development and testing of technologies in Alaska for Alaska situations. Basic research on wind turbines is done elsewhere.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

UA (ACEP, GI, IARC), AVEC, AEA, REAP

## TWG: Energy Supply and Demand

### 4.2.5.1

On-going research is needed to find suitable biomass technologies for generating power in the smaller communities that could simultaneously provide space heating. The biomass produced heat could be coupled with greenhouse production of food and energy crops. Algae, for example, could be grown in concentrated masses in greenhouses and converted to biofuels. Heat, light and CO2 from biomass burning could fuel the greenhouse operation. Little has been done in this area to prove the economics or other benefits of such an operation thereby limiting investment. A field-scale demonstration site would encourage the development of biomass generated heat and power (incl. food and energy) in Alaska.

Unique Identifier: 62

Overarching Need

#### Why is this an issue?

There is a need to optimize biomass development opportunities for rural heat and power as well as investigating the opportunities to cultivate biomass. For example, if willows can be cultivated and harvested for use in heat and power generation, the land area required for biomass production would be significantly reduced compared to harvesting of native biomass stands.

#### Describe the scope of the research need:

A field scale demonstration site is needed to conduct research into biomass cultivation and combustion. The demonstration site should offer opportunities for the public, small communities and cooperatives to learn about biomass production as well as conversion to energy and beneficial use of the excess heat, power, and CO2.

#### Policy option or recommendation:

This falls under the combined ESD Policy Options 7,8,9. The state should provide funding support for a feed and energy research station.

#### What research is being done/known?

There is presently work in agriculture that could help support a food and energy research station. The FNSB is in the process of leasing land to the Fairbanks Economic Development Corporation to start such a test site. The Food and Energy Research Station would be located in the Fairbanks area and would serve the state as a demonstration site for biomass cultivation and conversion to heat and power.

#### What are the gaps in research?

No work has been done to field test cultivation of crops for energy nor the beneficial use of excess heat, power and CO2 for greenhouse production of food and fuel crops.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling  Products  Education/Outreach  Data Management  Monitoring

#### Parties involved in implementation:

Fairbanks North Star Borough, USDA, DCCED, UAF, AEA, Fairbanks Economic Development Corporation

## TWG: Forestry, Agriculture and Waste Management

### 4.3.1.1

To develop a protocol for determining carbon sequestration rates, additionality for silvicultural treatments in boreal and coastal forests.

Unique Identifier: 116

Overarching Need

#### Why is this an issue?

Carbon trading under a cap and trade system requires verification of carbon additionality above a baseline reference. This "additional" C can be sold as part of a mitigation strategy for a C producer that needs to exceed their cap. Silvicultural treatments need rigorous third party review to ensure they meet the needs of the market.

#### Describe the scope of the research need:

-Coastal and boreal forests need work completed on this topic -Should look at both above ground biomass and soil biomass and C pools

#### Policy option or recommendation:

FAW-1, Establish a carbon accounting system for forestry practices

#### What research is being done/known?

There is both policy development and research being done in this arena, but not specifically related to silviculture treatments in these ecosystems. Modeling will play a key role, but protocols for developing a baseline and C accounting over time need more attention. A good paper to review on this topic is "Managed Forests in Climate Change Policy: Program Design Elements"

#### What are the gaps in research?

Soil dynamics are not well understood, especially in permafrost rich soils

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Natural Systems

#### Research category/type:

Modeling  Products  Education/Outreach  Data Management  Monitoring

#### Parties involved in implementation:

There are several parties that should be included: state and federal forest management agencies and private land owners that undertake active forest management practices, native corporations, University of Alaska (U.A.) land trust, mental health trust. In addition, there are third party organizations that currently certify forest management practices on private and public lands that are exploring the concept of C certification. The Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI) are two potential participants in implementation discussions. Carbon exchanges, such as the Chicago Climate Exchange (CCX) and other trading and broker organizations should also be consulted in this multi stakeholder effort.



## TWG: Forestry, Agriculture and Waste Management

### 4.3.1.2

**Refine global climate models for better understanding of regional variations within Alaska. Provide means to disseminate these data.**

Unique Identifier: 189

Overarching Need

**Why is this an issue?**

Better understanding of the effects of climate change. Improved monitoring and modeling data will allow for development and dissemination of environmental information and design criteria for use in adapting to climate change.

**Describe the scope of the research need:**

Refine global climate models for better understanding of regional variations within Alaska. Provide means to disseminate these data. Develop more detailed regional estimates of potential climate changes for Alaska using site specific estimates of temperature, precipitation, topography, etc. Establish means to effectively distribute details on varying climate changes statewide.

**Policy option or recommendation:**

None, but a research need identified by the FAW TWG

**What research is being done/known?**

Scenarios Network for Alaska Planning (SNAP) at the University of Alaska is working on refinement of various climate change models as they pertain to Alaska and some of the unique issues that need addressed.

**What are the gaps in research?**

Variables not assessed as part of SNAP and their current research effort.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

Alaska state agencies, UA research centers such as the Center for Knowledge Sharing on Climate Change and Arctic Issues, EPA, and other federal agencies.

## TWG: Forestry, Agriculture and Waste Management

### 4.3.1.3

**Assess contributions of CO<sub>2</sub> & CH<sub>4</sub> from melting permafrost to AK's GHG Emissions. Study of expected carbon losses during permafrost melt and addition of emissions to the AK GHG I&F.**

Unique Identifier: 191

Overarching Need

**Why is this an issue?**

Better understanding of the CO<sub>2</sub>e impacts of melting permafrost and appropriate representation in AK's GHG I&F. Potential for large impact to the I&F report if these areas are considered to be anthropogenic.

**Describe the scope of the research need:**

Review of existing modeling, if available, addition of results to the GHG I&F appendix for Forestry and Land Use. New modeling, if needed.

**Policy option or recommendation:**

None, but a research need identified by the FAW TWG

**What research is being done/known?**

Unknown

**What are the gaps in research?**

Unknown

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

University of Alaska research centers.

## TWG: Forestry, Agriculture and Waste Management

### 4.3.1.4

**Assess whether the Boreal forest should be considered managed or unmanaged and hence either considered either an anthropogenic or natural source (current consideration is as a natural source)**

Unique Identifier: 190

Overarching Need

**Why is this an issue?**

Determination of Coverage of carbon fluxes in the Boreal Forest as part of the Alaska GHG Inventory & Forecast. There is a potential for a large impact on the overall GHG emissions of the state if the Boreal Forest is considered a managed forest, and hence, an anthropogenic source of emissions.

**Describe the scope of the research need:**

Review IPCC materials on the definition of managed or unmanaged forests. Confer with in-state forestry experts to assess the proper classification of the Boreal Forest based on past and future management.

**Policy option or recommendation:**

None, but a research need identified by the FAW TWG

**What research is being done/known?**

None on this specific topic.

**What are the gaps in research?**

See scope of research need for discussion on this point.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

UA Research Centers, State Foresters, USFS

## TWG: Forestry, Agriculture and Waste Management

### 4.3.2.1

**Demonstrate that in arctic weather conditions, modern wood combustion appliances, such as wood pellet stoves, boilers and larger scale wood chip or co-fire facilities meet Environmental Protection Agency (EPA) particulate matter (PM-2.5) and other pollutant standards. This is very important for the communities of Fairbanks and Juneau which have been in violation of the new PM-2.5 standard and may have wood burning closures to help deal with the issue.**

Unique Identifier: 119

Overarching Need

#### Why is this an issue?

In an arctic climate wood burning appliances need testing for particulate matter (PM), nitrogen oxides (NO<sub>x</sub>) and carbon monoxide (CO) to ensure public health is not negatively impacted. Like other combustion systems wood boilers emit a variety of pollutants, including particulate matter, nitrogen oxides, carbon monoxide, volatile organic compounds (VOC), sulfur dioxide (SO<sub>2</sub>), carbon dioxide (CO<sub>2</sub>) and other pollutants. Wood boilers emit PM, NO<sub>x</sub>, and CO in much greater quantities than the other pollutants. For this reason, these are the three pollutants to track and carefully monitor to determine potential impacts. Wood systems also emit greater quantities of CO<sub>2</sub>, however unlike fossil fuels; woody biomass is considered carbon neutral. (See 118 for a more detailed discussion on this concept).

#### Describe the scope of the research need:

There are several different scales to address, from individual home appliances, to mid-size boilers for larger public facilities, such as schools. There may also be a need to look at co-firing uses, such as electric utilities where coal and wood chips are combusted together.

#### Policy option or recommendation:

FAW-2, Allay concerns that wood burning has detrimental health impacts

#### What research is being done/known?

Cold Climate Housing Research Center (CCHRC) in Fairbanks is doing some testing in conjunction with the Fairbanks North Star Borough (FNSB). The military did some emission tests on co-firing with wood chips and coal at Fort Wainwright in the 1980's. The Western Forestry Leadership Coalition has published an issue brief that provides a good summary on this topic.

#### What are the gaps in research?

Unregulated wood burning appliances, such as outdoor wood boilers, and EPA approved devices in arctic conditions.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Natural Systems

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

Department of Environmental Conservation (DEC), EPA, local governments and the legislature could all have roles in the implementation of this option. Joint effort by private and public sector such as: stove manufacturers, wood fuel manufactures, Cold Climate Housing Research Center (CCHRC), retailers of wood combustions devices and the Cooperative Extension Service.

## TWG: Forestry, Agriculture and Waste Management

### 4.3.3.1

**Development of a protocol that assigns a carbon life to different types of wood products, including durable wood products.**

Unique Identifier: 117

Overarching Need

#### Why is this an issue?

Currently in most models that portray carbon flux between sinks and sources there is no allocation made for C storage as a tree moves from a log to a forest product. When the tree is harvested from the forest, it is treated as an emission. This is a simplification that is not accurate in the real world use of wood.

Products substitution; using wood instead of steel, concrete or other building products that have much higher C footprint than wood. Life cycle assessment studies have conclusively shown marked differences in energy requirements associated with different building materials and structures made from them, yet current carbon trading protocols don't make allowances for this type of sequestration or reduction of GHG emissions.

#### Describe the scope of the research need:

A national or international standard needs developed so that the C market has the ability to certify and verify amounts of C stored by wood products

Carbon budgets need developed for different types of building materials to accurately portray the gain or loss of C based on the type of product used as compared to wood products

#### Policy option or recommendation:

FAW-1

#### What research is being done/known?

There are several papers that discuss this topic and the issues surrounding the concept. Dovetail Partners, Inc. have published a report entitled: Wood Products and Carbon Protocols Carbon Storage and Low Energy Intensity Should Be Considered and in Chapter 3 of the Society of American Foresters publication: Forest Management Solutions for Mitigating Climate Change in the United States there are also several good discussions on these topics.

#### What are the gaps in research?

Complete literature review to identify gaps, may be mostly policy gaps.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

Wood product manufacturing businesses, state and federal forest management agencies and private land owners. Alaska Forest Association, other. National or state level review of issue

## TWG: Forestry, Agriculture and Waste Management

### 4.3.3.2

**Determine if woody biomass used in energy production is a carbon neutral fuel source, Scientifically demonstrate that woody biomass used as a fuel for energy is a carbon neutral fuel**

Unique Identifier: 118

Overarching Need

#### Why is this an issue?

Currently woody biomass is considered a carbon neutral fuel when compared to fossil fuels, such as coal, oil or natural gas. The combustion of all fuels produces CO<sub>2</sub>, but trees that are harvested for this purpose are replaced by new trees that sequester C from the atmosphere. Over time, the CO<sub>2</sub> released by the combustion process will be captured again by the new tree crop. This concept is important because in the carbon trading market place, an offset credit can be generated by using a biomass fuel for a fossil fuel. It is a straight forward calculation to determine how much C is in a gallon of fuel oil or ton of coal and when you "offset" this fuel type with biomass you generate a credit that can be sold.

#### Describe the scope of the research need:

Scope is pretty narrow, need to demonstrate that this concept is valid or if not fully neutral by what percentage is it a Carbon neutral fuel?

#### Policy option or recommendation:

FAW-2

#### What research is being done/known?

Unknown, would benefit from a literature review

#### What are the gaps in research?

Not sure, it seems like a pretty straight forward problem that could be answered with current inventory and data. Needs re-worked from a Carbon perspective.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Natural Systems

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

Any biomass project would benefit so long as they are offsetting the use of a fossil fuel. Community governments, school districts, utilities, state or private institutions are all potential beneficiaries of this policy option. The research can be conducted at the University of Alaska, perhaps at the Center for Knowledge Sharing on Climate Change and Arctic Issues with assistance from staff at state and federal agencies.

## TWG: Oil and Gas

### 4.4.1.1

#### Economic: Impact of various incentives to major capital improvement investment

Unique Identifier: 130

Overarching Need

**Why is this an issue?**

This is an issue because incentives will drive a significant amount of private sector investment to reduce overall emissions and improve energy efficiency.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

There is no current research on this topic in Alaska

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Energy supply and demand

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

University, State Government; DNR, DOR

## TWG: Oil and Gas

### 4.4.1.2

#### Economic: Short and long term value of carbon

Unique Identifier: 128

Overarching Need

#### Why is this an issue?

Understanding the value of carbon will be critical in developing reasonable and affective policy for all CO2 mitigation activity. It will also be used to assess the economic impact of mitigation to the state.

#### Describe the scope of the research need:

The value of carbon on the local and global scale must be assessed for business models to have validity.

#### Policy option or recommendation:

The value of carbon must be determined to understand the impacts policy will have on commerce and state revenue. It will also be critical in order to design affective policy.

#### What research is being done/known?

Much research is being done on a national scale, yet understanding what the federal government will require is critical to the equation.

#### What are the gaps in research?

Pending regulation will have a huge affect on carbon values.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:



## TWG: Oil and Gas

### 4.4.1.3

#### Economic: Potential impact of carbon mitigation efforts on royalty revenue stream coming to the State of Alaska from O&G production

Unique Identifier: 131

Overarching Need

##### Why is this an issue?

Carbon mitigation costs will have a detrimental affect on the ultimate recovery of oil and gas in the state because of the, potentially large, impact on production costs and reduction of economically recoverable oil and gas.

##### Describe the scope of the research need:

Because the costs associated with carbon mitigation will be widely variant and dependant upon many factors, a broad scope of work must be accomplished.

##### Policy option or recommendation:

It is critical to understand the impacts of policy, if reasonable and non-damaging policy is to be developed

##### What research is being done/known?

A fair amount of national research is being done, but the impacts are very site specific.

##### What are the gaps in research?

Local variability and unique issue that will affect costs.

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

##### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

##### Parties involved in implementation:

## TWG: Oil and Gas

### 4.4.1.4

#### Technical: Regionally appropriate baseline mapping and monitoring of surface and subsurface (groundwater) hydrology

Unique Identifier: 127

Overarching Need

##### Why is this an issue?

Most areas of the state do not have adequate data on hydrology and what the affects development might have on requirements and impacts of surface and subsurface water resources.

##### Describe the scope of the research need:

The need for hydrologic baseline research is ubiquitous across the state and includes water quality and quantity and is necessary for any type development, including renewable energy or sequestration.

##### Policy option or recommendation:

Affects on and availability of water resources must be considered in any policy development or recommendation.

##### What research is being done/known?

Relatively small areas of the state are now being mapped and analyzed, but are limited in extend.

##### What are the gaps in research?

Energy supply and demand, and any other associated with development.

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

##### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

##### Parties involved in implementation:

State and federal regulatory and research agencies and the University

## TWG: Oil and Gas

### 4.4.1.5

**Technical: Regionally appropriate baseline physical mapping and imagery including bathymetry**

Unique Identifier: 126

Overarching Need

**Why is this an issue?**

So much of the current research is based on a solid foundation of baseline topographic and basic mapping and remote sensing that it is difficult to perform modern analyses without up to date DEMs, orthoimagry, and detailed geologic mapping. Unfortunately, Alaska is woefully lacking in much of this most basic information, and when compared to all other states, and most other countries, Alaska is literally in the ‘dark ages’ when it comes to baseline data.

**Describe the scope of the research need:**

Numerous baseline data sets are needed

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Oil and Gas

### 4.4.1.6

#### CO2 storage: Evaluate capacity of geologic and biologic sequestration in different regions of the State of Alaska

Unique Identifier: 132

Overarching Need

##### Why is this an issue?

Depending on what type of reductions mandates are adopted, understanding the capacity and location of viable sites, and the liabilities associated with those sites is critical.

##### Describe the scope of the research need:

The scope is limited to a few sequestration opportunities.

##### Policy option or recommendation:

Sequestration will be a limited option in many instances and should be carefully implemented. Government cannot mandate the existence of capacity

##### What research is being done/known?

The State DNR and federal DOE are engaged in a statewide preliminary analysis.

##### What are the gaps in research?

Detailed subsurface information is lacking in most areas of the state that need capacity information once the federal and state mandates are set out.

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Energy Supply and Demand

##### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

##### Parties involved in implementation:

## TWG: Oil and Gas

### 4.4.2.1

#### Economic: Short and long term value of natural gas

Unique Identifier: 129

 Overarching Need**Why is this an issue?**

Understanding the value of natural gas will allow a comparison of other forms of power generation at operations and will drive investment decisions on energy source.

**Describe the scope of the research need:**

The scope of this need is focused on oil and gas operations.

**Policy option or recommendation:****What research is being done/known?**

Research on this topic is likely being done within the industry and will have different parameters depending on company and location.

**What are the gaps in research?****If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Energy Supply and Demand

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

Industry and regulatory agencies

## TWG: Oil and Gas

### 4.4.3.1

#### CO<sub>2</sub> Storage: Evaluate enhanced hydrocarbon recovery options using CO<sub>2</sub> flooding and pressure support

Unique Identifier: 134

Overarching Need

##### Why is this an issue?

Enhanced Hydrocarbon recovery is one of the only CCS methods that derives economic benefit from the activity and increases ultimate recovery of a resource for the State.

##### Describe the scope of the research need:

The research on enhanced oil (EOR) and enhanced gas recovery (EGR) will be basin specific, and in many cases field specific.

##### Policy option or recommendation:

EOR and EGR feasibilities will help design incentive and regulatory programs

##### What research is being done/known?

Significant research in Nation, as well as within Alaska industry players.

##### What are the gaps in research?

How technologies can be applied to broader spectrum of fields, and specifically EGR.

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

##### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

##### Parties involved in implementation:

Industry, University, State Agencies, Federal Agencies

## TWG: Oil and Gas

### 4.4.3.2

#### CO2 Storage: Evaluate the feasibility of saline reservoir sequestration in non-marine basins prevalent throughout Alaska

Unique Identifier: 133

Overarching Need

##### Why is this an issue?

CO2 storage in saline reservoirs may become an issue in Alaska after conventional reservoirs are saturated, or in areas where no convention reservoirs exist (e.g., interior Alaska)

##### Describe the scope of the research need:

Saline reservoir sequestration research in Alaska must include long-term viability, EPA groundwater standards, liability issues, and existence of reservoir.

##### Policy option or recommendation:

It is important to understand the capacities of storages areas across the state for development planning purposes.

##### What research is being done/known?

A significant amount of research on this topic is underway nationally, but given the limited applicability in Alaska very little has been done.

##### What are the gaps in research?

Failure liability and technical feasibility are the greatest gaps in this research.

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

##### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

##### Parties involved in implementation:

## TWG: Oil and Gas

### 4.4.4.1

#### Technical: Feasibility of various entrained and exhaust CO2 capture technologies for North Slope and Cook Inlet

Unique Identifier: 121

Overarching Need

**Why is this an issue?**

Capturing CO2 from various exhaust systems will be a challenging effort and will need many new technologies.

**Describe the scope of the research need:**

Very broad and semi specific to source type.

**Policy option or recommendation:**

**What research is being done/known?**

A significant amount of research is on-going for specific applications, but will not transverse all needs.

**What are the gaps in research?**

Different applications will require different parameters and it will be very difficult to capture all scenarios.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Energy Supply and Demand

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**



## TWG: Oil and Gas

### 4.4.4.2

**Technical: Study where renewable energy sources co-exist with Oil and Gas operations**

Unique Identifier: 122

Overarching Need

**Why is this an issue?**

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

## TWG: Transportation and Land Use

### 4.5.1.1

#### Development of statewide tools for planning

Unique Identifier: 166

Overarching Need

**Why is this an issue?**

Need statewide planning tools to systematically evaluate GHG emissions on future scenarios

**Describe the scope of the research need:**

Develop tools that support scenario evaluation for planning options.

**Policy option or recommendation:**

NA

**What research is being done/known?**

Unknown

**What are the gaps in research?**

Scenarios need to be developed that are specific to the Alaskan environment. National level models don't work in Alaska. Alaska is a very diverse state geographically and we need models that can be applied to specific projects.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

## TWG: Transportation and Land Use

### 4.5.2.1

**Understand carbon cycle from cradle to grave to see if reducing tail pipe emissions is worthwhile. The carbon-cost of creating fuel needs to be included in the evaluation.**

Unique Identifier: 140

Overarching Need

#### Why is this an issue?

Decision makers need complete information to make valid data driven decisions. If only part of the carbon cycle is considered, the economics of decisions may not be realistic.

#### Describe the scope of the research need:

For each type of fuel, assess the total carbon cycle, including carbon outputs in the Alaskan environment to ensure the reduction in tailpipe outputs of carbon are not negated by the cost of producing or transporting the alternative fuel.

#### Policy option or recommendation:

T-5. Promotion of Alternative Fuel Vehicles

T-10. Alternative Fuels Research and Development

#### What research is being done/known?

No known research is being done on Alaska specific conditions.

#### What are the gaps in research?

How does the Alaskan environment impact the benefits of using alternative fuel vehicles? Do the transportation requirements for getting alternative fuels to Alaska significantly diminish the benefits of using alternative fuel vehicles?

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

## TWG: Transportation and Land Use

### 4.5.2.2

**Analyze the life-cycle GHG impacts of various alternative fuels in the Alaska context. Better understanding of the life-cycle GHG benefits of alternative fuels in Alaska**

Unique Identifier: 34

Overarching Need

**Why is this an issue?**

The life-cycle GHG impacts of alternative fuels depend heavily on emissions from fuel production and transport. Nearly all research to date has focused on the lower 48. GHG impacts in Alaska could be quite different. Need to understand which alternative fuels have GHG benefits in AK.

**Describe the scope of the research need:**

At a minimum, analysis should be done for:

- natural gas
- biodiesel
- ethanol

**Policy option or recommendation:**

**What research is being done/known?**

Modeling for US is being by Argonne National Labs, but is not specific to AK. Some states (such as CA) have done state-specific modeling.

**What are the gaps in research?**

life-cycle GHG impacts specific to AK.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

- Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

Alaska state agencies, UA research centers, EPA, DOE

## TWG: Transportation and Land Use

### 4.5.3.1

#### Development of methods or tools to accurately estimate GHG impacts of transportation plans in AK.

Unique Identifier: 36

Overarching Need

##### Why is this an issue?

Transportation agencies will soon be required to quantify GHG impacts of transportation plans. Tools and methods are being developed for lower 48. But arctic climate in AK might affect the GHG emissions from motor vehicles and necessitate tools or methods that are adapted to AK.

##### Describe the scope of the research need:

Develop tools similar to those being developed for the lower 48 with a focus on Alaska and the arctic. This should include the differences in how Alaskan's use vehicles. Many Alaskan communities are accessible only via aircraft. While the high energy prices are driving rural citizens to migrate to urban areas, the GHG emissions associated with additional VMT may offset the GHG emissions from aircraft. Therefore, the variety of transportation modes used in different parts of Alaska must be built in to the models.

##### Policy option or recommendation:

T-6. VMT and GHG Reduction Goals in Planning

##### What research is being done/known?

National research being done for U.S. EPA, TRB, FHWA.

##### What are the gaps in research?

No Alaska or arctic specific research

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

##### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

##### Parties involved in implementation:

Alaska DOT&PF, AMATS and FMATS

## TWG: Transportation and Land Use

### 4.5.3.2

**Investigate potential to reduce fuel use and GHG emissions by coordinating transportation networks and commercial fishery openings.**

Unique Identifier: 35

Overarching Need

**Why is this an issue?**

Excess fuel use and GHG emissions occur because of poor coordination of fishery openings.

**Describe the scope of the research need:**

Better understanding of the potential to reduce GHG emissions by coordinating transportation networks and commercial fishery openings.

**Policy option or recommendation:**

**What research is being done/known?**

None

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

Alaska Department of Energy; Alaska Board of Fisheries (BOF); Alaska DOT&PF

## TWG: Transportation and Land Use

### 4.5.4.1

**Determine GHG impacts of replacing older marine vessel engines with newer engines.**

Unique Identifier: 37

Overarching Need

**Why is this an issue?**

Newer marine engine have lower particulate matter emissions due to federal standards. But their effect on GHGs is uncertain.

**Describe the scope of the research need:**

Develop tools for better understanding of GHG impacts of modernizing marine vessel engines. Analyze the potential trade-off of reducing particulate pollution with GHG outputs.

**Policy option or recommendation:**

**What research is being done/known?**

May be recent or ongoing research by US EPA.

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

AK DEC; Alaska Board of Fisheries (BOF)

## TWG: Transportation and Land Use

### 4.5.5.1

**Evaluate the actual reduction of GHG from a pilot study of continuous descent approaches to Ted Stevens International Airport.**

Unique Identifier: 139

Overarching Need

**Why is this an issue?**

Aviation in Alaska has a disproportionate impact on GHG emissions compared to other forms of transportation. Focusing on aviation reductions may be an area where large reductions can be realized.

**Describe the scope of the research need:**

Real time activities are underway to enhance safety and reduce fuel usage on arrivals to Ted Stevens International Airport. Assessment of these activities should be undertaken to evaluate the impact to GHG emissions.

**Policy option or recommendation:**

T-9. Aviation Emissions Reduction

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**



## TWG: Transportation and Land Use

### 4.5.6.1

**Analysis to determine what is required to increase citizen use of public transportation and increase conservation efforts.**

Unique Identifier: 167

Overarching Need

**Why is this an issue?**

Need to understand what actions by the government result in greater use of public transportation and greater conservation efforts.

**Describe the scope of the research need:**

**Policy option or recommendation:**

T-1. Transit, Ridesharing, and Commuter Choice Programs

**What research is being done/known?**

Unknown

**What are the gaps in research?**

Unknown

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.1.1

**Develop higher resolution climate modeling and monitoring data and improve its accessibility and utility.**

Unique Identifier: 88

Overarching Need

**Why is this an issue?**

This need is common among nearly all the TWG. To assess and plan for changing economic conditions as a result of a changing climate will require higher resolution climate modeling and monitoring information at more local levels. Additionally, there is a need to increase the accessibility and utility of these data to government officials and businesses. Finally, there is a need to tailor these data to the needs of government officials and businesses.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.1.2

**Assess statutory, regulatory, and policy frameworks and barriers to implementing climate change policy recommendations.**

Unique Identifier: 89

Overarching Need

**Why is this an issue?**

Many laws, regulations and policies on the federal, state, and local levels were developed before the signs of more rapid climate change were recognized. For example, resource managers in Alaska may need to revise Alaska policies relative to wildland fire management in light of the effects of climate change. Another example is the need to modify water quality standards that call for maintenance of water temperatures in cold water systems in light of warming temperature. The challenge for government leaders and businesses will be to adapt to a future made less certain due to a more rapidly changing climate. This will necessitate an evaluation of existing laws, regulations and policies and possible changes to institutional, legal and policy frameworks in an adaptive manner.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.1.3

**Assess economic impacts of market-based approaches (e.g., cap and trade) to manage greenhouse gas (GHG) emissions and their impacts on the Alaskan economy.**

Unique Identifier: 90

Overarching Need

**Why is this an issue?**

Market-based approaches to manage GHG emissions can have a significant impact on many aspects of the Alaskan economy. It will be imperative to track these approaches as they develop and to proactively formulate strategies to adopt state approaches and, if necessary, adapt to adopted approaches.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.1.4

**Systematically identify and address economic barriers to implementing climate change planning efforts**

Unique Identifier: 91

Overarching Need

**Why is this an issue?**

Uncertainty associated with climate change may result in barriers to implement identified climate change strategies/options and planning efforts. It is important to identify these barriers and strategies for addressing them. The uncertainty and risk of the current predictions should be well understood and incorporated in the decision process.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.1.5

**Assess data and information (economic indicators) needed to develop or adapt short and long term planning tools to assess impacts of climate change on economic activities.**

Unique Identifier: 92

Overarching Need

**Why is this an issue?**

There is a lack of baseline economic information and data needed to develop or adapt both short and long term planning tools to implement identified climate change strategies and options. It is critical to identify and collect the needed economic indicators.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.1.6

**Implement adaptive (scenario-based) planning tools that integrate economic indicators to improve climate change mitigation and adaptation decision-making and implementation.**

Unique Identifier: 93

Overarching Need

**Why is this an issue?**

Successful implementation of climate change strategies/options will require development and implementation of adaptive planning tools. These tools need to be probabilistic and scenario-based and integrate economic indicators.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.1.7

**Catalog and assess new or expanded economic opportunities that may become available with climate change.**

Unique Identifier: 94

Overarching Need

**Why is this an issue?**

While some existing economic activities may be deleteriously affected by a changing climate, others may be benefited while still others may become established. For example, a warming climate may open new economic opportunities in the Arctic basin, including commercial fishing and transpolar shipping. A necessary first step towards developing these opportunities is to catalog and assess them.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**



## TWG: Economic Activities

### 5.1.10.1

**Assess how climate change will impact application of federal, state, and local laws, regulations and policies on energy demand and use.**

Unique Identifier: 172

Overarching Need

**Why is this an issue?**

Climate change legislation will impact application of federal, state, and local laws, regulations and policies on energy demand and use. For example, increased pressure to reduce GHG will have impacts on laws, regulations, and policies related to natural resources. For this reason it is imperative to assess how climate change will impact application of federal, state, and local laws, regulations and policies on energy demand and use.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.11.1

**Assess how climate change will impact application of federal, state, and local laws, regulations and policies on economic development activities.**

Unique Identifier: 173

Overarching Need

**Why is this an issue?**

Climate change legislation will impact application of federal, state, and local laws, regulations and policies on economic development activities. For example, increased Arctic shipping and resource development will have impacts on laws, regulations, and policies related to natural resources and indigenous people. For this reason it is imperative to assess how climate change will impact application of federal, state, and local laws, regulations and policies on economic development activities.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

**TWG: Economic Activities****5.1.12.1**

Continue to refine the “Cost of Climate Change” study recently completed by the UAA ISER.

Unique Identifier: 174

Overarching Need

**Why is this an issue?**

The University of Alaska Institute of Social and Economic research is conducting a study to assess the costs of climate change to Alaska. This is an overarching economic analysis of the climate related impacts. This study should be completed.

**Describe the scope of the research need:****Policy option or recommendation:****What research is being done/known?****What are the gaps in research?****If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?****Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.12.2

Identify climate trends and downscale models leading to establishing environmental information, analysis tools, and design criteria for use in adapting to climate change.

Unique Identifier: 175

Overarching Need

**Why is this an issue?**

This need is common among nearly all the TWG. To assess and plan for changing economic conditions as a result of a changing climate will require higher resolution climate modeling and monitoring information at more local levels. Additionally, there is a need to increase the accessibility of these data to government officials and businesses. Finally, there is a need to tailor these data to the needs of government officials and businesses.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.12.3

**Provide resources for good Digital Elevation Model (DEM) and GIS data, and current and high resolution imagery to establish a more robust information infrastructure to plan and adapt.**

Unique Identifier: 176

Overarching Need

**Why is this an issue?**

There is a need for improved Digital Elevation Model (DEM) and GIS data, and current and high resolution imagery to establish a more robust information infrastructure to plan and adapt. This information is needed to develop down-scaled models and to assess potential economic impacts.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

**TWG: Economic Activities****5.1.12.4**

**Invest in monitoring and data dissemination programs to enhance information available for safe and efficient resource development.**

Unique Identifier: 177

 Overarching Need**Why is this an issue?**

Much data is currently available but for a variety of reasons is unavailable to researchers or decision-makers. There is an urgent need to invest in monitoring and data dissemination programs to enhance information available for safe and efficient resource development.

**Describe the scope of the research need:****Policy option or recommendation:****What research is being done/known?****What are the gaps in research?****If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?****Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.2.1

**Develop economic analysis of potential rise or decline of oil and gas development on state revenues.**

Unique Identifier: 95

Overarching Need

**Why is this an issue?**

Oil and gas production provides significant revenues to Alaska. As such, any changes to oil and gas production can be expected to have significant impacts to the Alaskan economy. Climate change and resultant efforts to mitigate for it, or adapt to it, is expected to have impacts to oil and gas production. For example, development of cap and trade programs could have significant impacts on oil and gas production. Given the likelihood of such impacts it is imperative to develop economic analysis of potential rise or decline of oil and gas development on state revenues.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Energy Supply and Demand

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.2.2

Consider how potential rise or decline of oil and gas operation and maintenance may affect state revenues.

Unique Identifier: 96

Overarching Need

**Why is this an issue?**

Climate change is expected to have impacts on oil and gas operations and maintenance. Under current tax structures, operation and maintenance costs can influence the amount of revenue the state receives from production. For this reason, it is important to determine how potential rise or decline of oil and gas operation and maintenance may affect state revenues.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Oil and Gas

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**



## TWG: Economic Activities

### 5.1.2.3

**Model coastal vulnerability to establish criteria for pipeline coastal transition set-backs and burial depths.**

Unique Identifier: 97

Overarching Need

**Why is this an issue?**

Climate change is expected to impact coastal zones through erosion and coastal inundation. This will require an assessment of the current permitting and oversight of pipelines and other operations in the coastal zone. This assessment will require a modeling of coastal vulnerability to establish criteria for pipeline coastal transition set-backs and burial depths.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Public Infrastructure and Oil and Gas

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.2.4

**Expand research on ice road and pad construction techniques and in-season monitoring to maximize seasonal use and minimize impacts.**

Unique Identifier: 98

Overarching Need

**Why is this an issue?**

Climate change is impacting the length of time ice roads and pads can be used on the North Slope of Alaska. Expanded research on ice road and pad construction techniques and in-season monitoring is needed to maximize seasonal use and minimize impacts.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Public Infrastructure and Oil and Gas

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.2.5

**Expand research on climate change impacts on permafrost engineering design.**

Unique Identifier: 99

Overarching Need

**Why is this an issue?**

Permafrost is being impacted by climate change. These impacts are affecting existing and planned structures. Design standards are inadequate to address these impacts. Expanded research on climate change impacts on permafrost engineering design is needed.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Public Infrastructure and Oil and Gas

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

**TWG: Economic Activities****5.1.2.6****☑ Develop new techniques to clean up oil spills in icy waters.**

Unique Identifier: 100

 Overarching Need**Why is this an issue?**

There is an interest in developing offshore oil and gas in Arctic areas. This increases the potential for oil spills in offshore areas that are being impacted by changing ice conditions associated with climate change. There is a need to develop new techniques to plan for and clean up oil spills in icy waters.

**Describe the scope of the research need:****Policy option or recommendation:****What research is being done/known?****What are the gaps in research?****If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Oil and Gas

**Research category/type:** Modeling    Products    Education/Outreach    Data Management    Monitoring**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.3.1

#### Assess economic potential for developing carbon-neutral energy sources

Unique Identifier: 101

Overarching Need

#### Why is this an issue?

Federal legislation may likely call for a larger proportion of energy production to come from carbon-neutral sources (definition, e.g. including forest materials). In Alaska, little is known about the economic potential for developing carbon-neutral energy sources. Given this, it is imperative to assess the potential for developing carbon-neutral energy sources.

#### Describe the scope of the research need:

#### Policy option or recommendation:

#### What research is being done/known?

#### What are the gaps in research?

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Energy Supply and Demand

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

## TWG: Economic Activities

### 5.1.3.2

Identify potential economies of scale and return on investments in developing renewable energy sources.

Unique Identifier: 102

Overarching Need

**Why is this an issue?**

Little is known about the long-term economics associated with renewable energies. As there is an increased call for shifting energy production to renewable energy sources it is important to identify potential economies of scale and return on investments in developing renewable energy sources. This will allow better decision tools to be developed to inform the economic impacts of renewable energy sources.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Energy Supply and Demand

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.4.1

**☑ Research cost-effective techniques for construction, operation, and reclamation that will be responsive and useful in changed environmental conditions.**

Unique Identifier: 103

Overarching Need

**Why is this an issue?**

Energy conservation and renewable energy alternatives require metals and metal alloys. As renewable energies increase, this will increase the demand for metals. Since Alaska has world class metal resources, it can be expected that there may be increased interest in mining. It will be important to research cost-effective techniques for construction, operation, and reclamation that will be responsive and useful in changed environmental conditions.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Public Infrastructure, Natural Systems, Energy Supply and Demand.

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.4.2

#### Assess engineering standards for tailings storage in Arctic/Subarctic climates.

Unique Identifier: 104

Overarching Need

**Why is this an issue?**

Energy conservation and renewable energy alternatives require metals and metal alloys. As renewable energies increase, this will increase the demand for metals. Since Alaska has world class metal resources, it can be expected that they will be increased interest in mining. As new mines are developed it will be important to assess engineering standards for tailings storage in Arctic/Subarctic climates.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Public Infrastructure, Natural Systems, Energy Supply and Demand

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**



## TWG: Economic Activities

### 5.1.4.3

**Develop economic analyses of potential rise or decline of mining and impact on state revenues.**

Unique Identifier: 105

Overarching Need

**Why is this an issue?**

Energy conservation and renewable energy alternatives require metals and metal alloys. As renewable energies increase, this will increase the demand for metals. Since Alaska has world class metal resources, it can be expected that they will be increased interest in mining. As this demand increases it will be important to develop economic analyses of potential rise or decline of mining and impact on state revenues.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Public Infrastructure, Natural Systems, Energy Supply and Demand

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

**TWG: Economic Activities****5.1.5.1****Model sea ice and its effect on ocean transportation.**

Unique Identifier: 106

 Overarching Need**Why is this an issue?**

Climate change is reducing sea ice in the Arctic at varying rates. It is important to model sea ice and its effect on ocean transportation.

**Describe the scope of the research need:****Policy option or recommendation:****What research is being done/known?****What are the gaps in research?****If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Natural Systems, Public Infrastructure

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.5.2

**Develop economic analysis of potential rise or decline of shipping and impact on state revenues.**

Unique Identifier: 107

Overarching Need

**Why is this an issue?**

Climate change is reducing sea ice in the Arctic, creating economic opportunities and localized costs. It is important to assess the impacts of increased shipping to Alaska and its economy.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Natural Systems, Public Infrastructure

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.5.3

Identify trends that may influence impacts of shipping on the environment, hunting, fishing and communities.

Unique Identifier: 108

Overarching Need

**Why is this an issue?**

Climate change is reducing sea ice in the Arctic and allowing for increased shipping. This will potentially influence the environment, hunting, fishing and coastal communities. As such it is necessary to identify trends that may influence impacts of shipping on the environment, hunting, fishing and communities.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Natural Systems, Public Infrastructure

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

**TWG: Economic Activities****5.1.5.4****Increase ice-breaking capabilities in the Arctic.**

Unique Identifier: 109

 Overarching Need**Why is this an issue?**

Climate change is impacting the formation and breakup of sea ice in the Arctic. To increase the duration of shipping and provide for assistance in sea ice conditions, ice-breaking will be required. For these reasons it is imperative to Increase ice-breaking capabilities in the Arctic.

**Describe the scope of the research need:****Policy option or recommendation:****What research is being done/known?****What are the gaps in research?****If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Public Infrastructure

**Research category/type:** Modeling     Products     Education/Outreach     Data Management     Monitoring**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.5.5

**Research innovative approaches and building techniques for supporting arctic shipping and developing sustainable ports.**

Unique Identifier: 110

Overarching Need

**Why is this an issue?**

Climate change is changing sea ice formation and breakup in the Arctic, which will change how ports are developed and shipping routes maintained. This will require research into innovative approaches and building techniques for supporting arctic shipping and developing sustainable ports.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Public Infrastructure

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

**TWG: Economic Activities****5.1.6.1****Assess the impact of climate change on existing rural transportation networks.**

Unique Identifier: 111

 Overarching Need**Why is this an issue?**

Much of Alaska's rural transportation network is non-road based, depending on frozen tundra and unfrozen river and lake routes for surface transportation. As a result, climate change can potentially significantly affect these networks. For these reasons, it is imperative to assess the impact of climate change on existing rural transportation networks.

**Describe the scope of the research need:****Policy option or recommendation:****What research is being done/known?****What are the gaps in research?****If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Public Infrastructure and Health and Culture

**Research category/type:** Modeling    Products    Education/Outreach    Data Management    Monitoring**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.6.2

**Develop economic analysis of potential costs associated with expected impacts to rural transportation networks.**

Unique Identifier: 112

Overarching Need

**Why is this an issue?**

Much of Alaska's rural transportation network is non-road based. As a result, climate change can potentially significantly affect these networks. With increases to costs of transportation, it is important to develop economic analysis of potential costs associated with expected impacts to rural transportation networks.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Public Infrastructure and Health and Culture

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**



## TWG: Economic Activities

### 5.1.7.1

**Develop economic analysis of potential rise or decline of recreational, subsistence and commercial fishing.**

Unique Identifier: 113

Overarching Need

**Why is this an issue?**

Climate change will impact fish and their habitats to varying degrees. Some fisheries will benefit while others will be negatively impacted. Research into fisheries should support develop economic analysis of potential rise or decline of recreational, subsistence and commercial fishing.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Natural Systems, Health and Culture

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

**TWG: Economic Activities****5.1.7.2****Assess and model increased insurance costs.**

Unique Identifier: 114

 Overarching Need**Why is this an issue?**

Climate change is recognized as causing increased risks to private and government infrastructure. Insurance premiums are based on environmental conditions and projected risks. It will be important to assess and model insurance costs associated with risks perceived from climate change influences.

**Describe the scope of the research need:****Policy option or recommendation:****What research is being done/known?****What are the gaps in research?****If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Public Infrastructure and Health and Culture

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.8.1

**Develop economic analysis of potential rise or decline of tourism and impact on state revenues.**

Unique Identifier: 115

Overarching Need

**Why is this an issue?**

Tourism is an increasing contributor to the Alaskan economy. It is unknown how a changing climate may impact tourism. It is important to develop economic analysis of potential rise or decline of tourism and impact on state revenues related to climate change.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Natural resources, Public Infrastructure, Health and Culture

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.8.2

**Develop economic (scenario) analysis of potential national and international changes in patterns of people and freight movements.**

Unique Identifier: 169

Overarching Need

**Why is this an issue?**

Climate change is impacting natural systems throughout the Arctic, both in the terrestrial and ocean areas. The impact to these natural systems will likely change the patterns of movement of people and freight. It is important to develop economic (scenario) analysis of potential national and international changes in patterns of people and freight movements.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Public Infrastructure, Health and Culture

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

**TWG: Economic Activities****5.1.8.3**

**Assess opportunities for development/enhancement of recreation due to climate change.**

Unique Identifier: 170

Overarching Need

**Why is this an issue?**

Climate change is impacting natural systems throughout the Arctic with changes to seasonal recreation. It is imperative to assess opportunities for development/enhancement of recreation due to climate change.

**Describe the scope of the research need:****Policy option or recommendation:****What research is being done/known?****What are the gaps in research?****If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Natural resources, Public Infrastructure, Health and Culture

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

## TWG: Economic Activities

### 5.1.9.1

**Improve mapping and surveying to accurately and efficiently establish boundaries, address boundary disputes as needed and aid charting for safe navigation.**

Unique Identifier: 171

Overarching Need

**Why is this an issue?**

As climate changes, boundaries that are dependent upon physical features may be impacted. It is necessary to improve surveying and mapping to accurately display the land and land/water interface. This will support establishing boundaries and provide data to address boundary disputes. Improved charting for safe navigation and mapping for overland travel will be an ancillary product.

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Natural resources, Public Infrastructure

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Health and Culture

### 5.2.1.1

**Regional economic models to quantify climate change impacts on communities and provide input to the NEPA process.**

Unique Identifier: 83

Overarching Need

**Why is this an issue?**

Communities can not adapt to the impacts of climate change without state and federal assistance, which requires compliance with the NEPA process and recommended alternatives. Climate change is raising significant economic questions with investment in communities and sustainability.

**Describe the scope of the research need:**

Economic models are needed that address the cost to adapt communities to a changing climate. This includes costs to maintain the community to preserve the culture, increase medical services with potential events and stresses, and determine the sustainability.

**Policy option or recommendation:**

**What research is being done/known?**

An economic model has been built for the risk to public infrastructure. Other economic models have components of subsistence as a factor in determining economic value of impacted communities.

**What are the gaps in research?**

Economic value of culture and costs to replace traditional knowledge and wisdom and traditional ecological knowledge are gaps that requires quantification.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Public Infrastructure and Economic Activities

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

US Army Corps of Engineers, EPA, BIA, NOAA and AK DCCED, DNR and DEC

## TWG: Health and Culture

5.2.1.10

**Refine global climate models for better understanding of regional variations within Alaska. Provide means to disseminate these data. Modeling. Better understanding of the effects of climate change**

Unique Identifier: 29

Overarching Need

### Why is this an issue?

Improved monitoring and modeling data will allow for development and dissemination of environmental information and design criteria for use in adapting to climate change

### Describe the scope of the research need:

1. Develop more detailed regional estimates of potential climate changes for Alaska using site specific estimates of temperature, precipitation, topography, etc. 2. Establish means to effectively distribute details on varying climate changes statewide

### Policy option or recommendation:

Develop higher resolution climate monitoring and modeling

### What research is being done/known?

SNAP

### What are the gaps in research?

Variables not assessed as part of SNAP

### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

### Research category/type:

Modeling  Products  Education/Outreach  Data Management  Monitoring

### Parties involved in implementation:

Alaska state agencies, UA research centers, EPA, other federal agencies



## TWG: Health and Culture

### 5.2.1.11

Assess the degree and rate of thawing submarine permafrost deposits in coastal areas due to warming sea temperatures. Evaluate the risk of subsidence and erosion and the consequent impact on human developments and ecosystems. Study of Climate Driven Instability of Coastal Permafrost.

Unique Identifier: 76

Overarching Need

#### Why is this an issue?

Newtok relocated because of the thawing of subterranean and submarine permafrost. Other coastal communities in western, northwest and northern Alaska have comparable risk with retreat of sea ice.

#### Describe the scope of the research need:

Standard permafrost measurement techniques will provide the data to develop assessments. Research needs to be completed in conjunction with coastal mapping and establishing vertical control.

#### Policy option or recommendation:

#### What research is being done/known?

US Army Corps of Engineers has researched conditions at Newtok

#### What are the gaps in research?

Limited understanding

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Public Infrastructure and Natural Systems

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

US Army Corps of Engineers, UA

## TWG: Health and Culture

### 5.2.1.12

Consider developing a television program similar to Alaska Weather that provides climate change projection information and data on issues of specific importance to Alaska’s rural communities. Such a program would foster better understanding of how changes in future climate, both gradual and sudden, can impact communities and individual lives. This can become a catalyst for change in individual behavior. Research Ways to Improve Data Sharing Across Scales: Example: Increase Public Understanding and Recognition of Climate Change Impacts

Unique Identifier: 78

Overarching Need

#### Why is this an issue?

Public understanding of climate change and impacts to the health of the people and their culture is needed.

#### Describe the scope of the research need:

Research what is needed to present culturally accurate and appropriate materials and interviews for the program. Research sources of sponsorship and supporting materials.

Research network coverage and programs that may already be presenting information identified

#### Policy option or recommendation:

#### What research is being done/known?

Unknown, although non-profits and other entities outside the research community may be able to define what has been and is being done.

#### What are the gaps in research?

Research of the archive of Alaska climate change articles, programs and mini-series need to be completed.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

## TWG: Health and Culture

### 5.2.1.13

Research and develop culturally appropriate curriculums and materials for traditional knowledge and local observations with accuracy of observations versus traditional knowledge and wisdom. Resolving the question of how accurate are low tech monitoring versus local observations may need to be resolved through social science methods. Determining whether lowering standards for local observations for a culture based on observations is effective or creating further communication barriers may require social and cultural research.

Unique Identifier: 163

Overarching Need

#### Why is this an issue?

Community buy-in and cultural acceptance needs to have the education and tools to be implemented.

#### Describe the scope of the research need:

##### Policy option or recommendation:

Education component shared system for infrastructure observations use workforce to provide information into database:

Option1: Look at low-tech monitoring techniques, satellite imaging

-Local data observations with less than full weather service standards

-New sensors w communications systems. Use vehicles as probes

##### What research is being done/known?

Research is ongoing in finding local community members and programs.

##### What are the gaps in research?

Local climate change monitoring may not be recognized as cross-cutting to cultures and linked to acceptance of traditional knowledge and wisdom as a standard for observations and communications. Research plans that show how the two work together may prove beneficial.

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

##### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

##### Parties involved in implementation:

UA, ICC, NOAA, others

## TWG: Health and Culture

### 5.2.1.14

**Improve communications between federal scientists and state government agencies (such as the Alaska Departments of Fish and Game, Environmental Conservation, and Natural Resources) on climate science, the potential impacts, and data needs for those agencies concerning climate change. Research Ways to Improve Data Sharing Across Scales: Example: Bridge Gaps between State and Federal Science and Resource Agencies**

Unique Identifier: 79

Overarching Need

#### Why is this an issue?

Concern that the information is not accurate or all inclusive. Decision makers do not make decisions or communities have insufficient information to make an informed decision.

The other question is why is this an issue with the number of working groups that have collaborated for decades. Is it because the issue of climate change is so large and cross cutting that not all agencies are able to focus on the breadth of research needed. The Governor's sub-cabinet and working groups are an example of an effective method to address this issue.

#### Describe the scope of the research need:

Research is needed on the most effective way for data delivery and key word indexing, as disciplines speak in different languages.

#### Policy option or recommendation:

Establish and maintain a joint federal/state/public entity working group to develop guidance on interagency gaps.

#### What research is being done/known?

Unknown

#### What are the gaps in research?

No gaps in research. Gaps in priority use of research funding and networking opportunities, as well as leadership commitment of resources may be the critical gaps

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

Federal Executive Roundtable, Governor's Sub-cabinet, AGDC, ACCAP, International Forums, etc.

## TWG: Health and Culture

### 5.2.1.2

**Revised Flood Risk Maps. Use projections for increased precipitation, loss of sea ice and the accompanied increase in storm activity over previously ice covered waters for the next 100 years to develop revised flood risk maps that will help guide communities and state agencies in making future planning and infrastructure development decisions. Allow for continual update of these maps to incorporate the expected ongoing refinement in climate projections over time.**

Unique Identifier: 70

Overarching Need

#### Why is this an issue?

Communities can not obtain flood insurance. Securing funding for improving and maintaining community will be difficult as lack of information and accurate data will require conservative attitudes towards investment and economic development. This will hinder economic development for the community.

#### Describe the scope of the research need:

Updating the Precipitation Frequency Estimates (PFE) will require local collection of precipitation in each community. Developing education materials that encourage local monitoring and reporting of precipitation is needed. Analyzing storm frequency and intensity is an essential part of this effort. Ice retreat for coastal inundation and ice jamming for river flooding need to be documented for frequency and forecast based on hindcast of events.

#### Policy option or recommendation:

#### What research is being done/known?

National Weather Service is updating their cooperative observing network to compile precipitation data for updating Alaska PFE for more comprehensive data coverage.

DCCED is working to update Flood Plain Maps for NFIP.

DEM&HS is updating disaster risk maps based on past 27 years of history.

#### What are the gaps in research?

Data collection and analysis. Accurate contouring of rural Alaska communities on community maps.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Public Infrastructure, Economic Activities, and Natural Systems

#### Research category/type:

Modeling  Products  Education/Outreach  Data Management  Monitoring

#### Parties involved in implementation:

## TWG: Health and Culture

### 5.2.1.3

Develop sea level rise projection maps for coastal areas throughout Alaska, accounting for local isostatic rebound in conjunction with global sea level rise predictions. Work with coastal communities and the state of Alaska to incorporate this information into community and state planning efforts to better guide future development decisions. Allow for continual update of these maps to incorporate the expected ongoing refinement in climate projections over time. **Sea Level Rise Projection Mapping.**

Unique Identifier: 72

Overarching Need

#### Why is this an issue?

Communities are unable to accurately plan for economic development and assess risks from erosion or inundation. Public is developing inaccurate perception of sea level rise and coastal inundation because of lack of accurate information and heavy press coverage.

#### Describe the scope of the research need:

Research needs to establish the vertical datum in coastal Alaska, particularly for western and northwestern Alaska and the north slope. Measurement must include accurate shoreline mapping to depict trends associated with erosion and accretion. Tidal measurements will be required to determine changes in the frequency of storm surges and provide the data to document sea level rise.

#### Policy option or recommendation:

#### What research is being done/known?

NOAA and USGS have ongoing programs. State is looking into digital mapping initiative (SDMI)

#### What are the gaps in research?

Costs of collecting data and establishing stations in western and northern Alaska.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Public Infrastructure, Natural Systems, and Economic Activities

#### Research category/type:

Modeling  Products  Education/Outreach  Data Management  Monitoring

#### Parties involved in implementation:

NOAA, USGS, AK DNR, DCCED and UA

## TWG: Health and Culture

### 5.2.1.4

Alaska's communities will have significant challenges in adapting if climate modeling projections downscaled to the local or regional level is not available on which to base decisions. They will also have little incentive to adapt. Currently, ACCAP has identified global circulation models (GCM) best suited to northern latitudes, and can downscale the model results to every community in the state. Disseminating this information to communities is a first step toward helping them to plan and tailor adaptation to their own specific needs and impacts. However, data gaps remain. Information on projected changes to permafrost and sea level at the local and regional levels is still lacking. Development of a statewide research grant fund could be used to focus the scientific community on filling data gaps critical to community adaptation. **Develop Downscaled Climate Modeling for Municipalities.**

Unique Identifier: 73

Overarching Need

#### Why is this an issue?

Communities are coping with changes as seen over time while decision makers are looking for more accurate information to plan and predict actions that will be required. Research that will downscale models is identified as one solution.

#### Describe the scope of the research need:

Research needs include more data collection and analysis as models can only be scaled to data density and longevity available.

#### Policy option or recommendation:

Cost/benefit analyses should be conducted to determine the value of downscaled models in the decision process, so that the value of a funding strategy can be realized and/or defended.

#### What research is being done/known?

NOAA, NASA, NSF, ONR, other public science agencies and many universities are downscaling models for accuracy and reliability.

#### What are the gaps in research?

Downscaled models are not accurate assessment tools for each individual community as a means to discuss and decide the socio-economic and cultural costs against a determinable timeline. Conducting social science applied research will take these from physical models to socio-economic models that will serve community needs in adapting to climate change.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

NOAA, NASA, IARC, UA

## TWG: Health and Culture

### 5.2.1.5

A strong need exists for a comprehensive inventory of the wide range of data collection, monitoring efforts, and research projects underway or planned in relation to the impacts of climate change on the environment. The benefit to federal, state and municipal entities of having this information accessible in some form of centralized information portal, gateway, or web-based clearinghouse would be significant, most notably in terms of improved ability to make adaptation decisions intelligently and effectively. In turn, duplication of monitoring efforts could be avoided and government entities could provide feedback on specific data gaps, serving to drive future research objectives. Conduct a Comprehensive Inventory of Current Research, Monitoring and Data Collection Efforts.

Unique Identifier: 69

Overarching Need

#### Why is this an issue?

Overall perception that the communities and decision makers do not have adequate information on the research projects ongoing to make plans to adapt to changing climate. There is limited understanding of the timeline by which the research will be conducted, analyzed and developed into applied research and information. With the days of internet and modern communication technology, impacted Alaska communities need access to up to date information and the ability to help guide research projects.

#### Describe the scope of the research need:

#### Policy option or recommendation:

#### What research is being done/known?

Federal Agencies are maintaining data archives, Universities have catalogs, and national climate change programs have research plans and programs.

#### What are the gaps in research?

No gaps in research, just gaps in communication and documentation followed by limited time to conduct the research of sources while completing their own research.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:



## TWG: Health and Culture

### 5.2.1.6

**This research need is being addressed in the Public Infrastructure Working Group. Social research that will address the cultural impediments and history of government providing to communities may provide insight into how to sustain communities and maintain community infrastructure to different cultural standards, while recognizing the challenges of weather and seasons.**

Unique Identifier: 165

Overarching Need

#### Why is this an issue?

Community based reporting and protocols can insure longevity in public and private investment while fostering agreement to maintain systems to higher standards. Costs and sources of funding are major issues in this area.

#### Describe the scope of the research need:

Socio-economic research that addresses investment, operations and maintenance, and longevity based on climate impacts and limits in cash economies to maintain the investment.

#### Policy option or recommendation:

Education component shared system for infrastructure observations use workforce to provide information into database:  
Option 3:

- move to probabilistic approach, make sure we can keep up with codes
- No reward system for taking care of what you have.
- Reward for destroying what you have through replacement
- No systematic decision-making process
- Fix from disaster—why build new when we can't maintain old?

#### What research is being done/known?

This area has been extensively discussed in the PI TWG. However the economic challenges of operations and maintenance versus construction requires additional research, economic modeling and cultural analysis.

#### What are the gaps in research?

Socio-economic and cultural research for the value of maintaining the communities infrastructure and visual appearance (social satisfaction) versus prioritizing use of funds versus other community needs. Research into the costs of deferred maintenance.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

## TWG: Health and Culture

### 5.2.1.7

**Social and Education research to develop culturally appropriate curriculums for maintaining public infrastructure and community property. Develop economic forecast models that show the cost savings by not deferring maintenance or in determining where deferred maintenance goes from cost savings to higher costs.**

Unique Identifier: 164

Overarching Need

#### Why is this an issue?

This is a continuation of the research needs associated with the public infrastructure TWG.

#### Describe the scope of the research need:

Work with Alaska communities to document the investment in maintenance, the levels of deferred maintenance and the costs to repair or replace. This needs to be linked to the increased damage from freeze and thaw cycles during any winter period. Take results and develop workforce curriculum to stimulate people to invest in their community for social satisfaction through well maintained personal/private infrastructure. This will allow for a quality workforce in maintaining public infrastructure and competing for local work.

#### Policy option or recommendation:

Education component shared system for infrastructure observations use workforce to provide information into database:

Option 2: Get good inventory of what we have, condition, vulnerability and reliability

-How do you collect and summarize data, maybe web based

-Use as education tool. Educate people about value of maintaining infrastructure

#### What research is being done/known?

Need to check with state and federal agencies as well as economic research groups and ISER.

#### What are the gaps in research?

Gaps exist in assessing the level of deferred maintenance

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

AK DCCED, BIA, DOTPF, other agencies

## TWG: Health and Culture

### 5.2.1.8

**Standardized Social Network research needs to be accomplished in select communities to understand potential impacts of relocation on social, sharing, economic and subsistence networks.**

Unique Identifier: 82

Overarching Need

**Why is this an issue?**

Standardized sampling methods for social networks, as being applied in different locations and for different cultures, can provide a tool by which the challenges facing Alaska communities can be better understood.

**Describe the scope of the research need:**

Research needs to identify the methodology used in different locations and cultures of indigenous people and small remote communities facing a change to culture and lifestyle with climate change. Compare questions and approaches for appropriateness to challenges being faced in Alaska. Tailor standardized research to culturally appropriate materials for Alaska's indigenous people.

**Policy option or recommendation:**

Apply methods as being used for indigenous people around the world that are facing impacts from climate change.

**What research is being done/known?**

The Inuit Circumpolar Council Indigenous Peoples workshop in Anchorage as a significant reference point.

**What are the gaps in research?**

Review existing social network research data for Alaska communities and people that are at risk from impacts of climate change. Assess adequacy of research questions and methodology to insure it is appropriate for the challenges faced across Alaska's people. Develop deterministic models to predict sustainability, outmigration and other risks with changes to the environment from climate change.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Economic Activities and Natural Systems

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

UA, ISER, ADF&G, DEC, Native Organizations

## TWG: Health and Culture

### 5.2.1.9

Using the SPOT satellite data system or others, to track changes in permafrost extent and work to develop projection maps for changes in extent over the next 100 years, based on climate change projections. Such data would serve to guide communities and state agencies in construction planning decisions, both for determining the location and means of construction of new projects as well as identifying those existing projects which may be at risk from thawing permafrost in the future. Allow for continual update of these maps to incorporate the expected ongoing refinement in climate projections over time.  
**Permafrost Extent Projection Mapping**

Unique Identifier: 71

Overarching Need

#### Why is this an issue?

Communities need accurate data to understand changes to their community and surrounding environment. This will support subsistence

#### Describe the scope of the research need:

This is a data acquisition approach that is being discussed for the Statewide Digital Mapping Initiative

#### Policy option or recommendation:

#### What research is being done/known?

This is being done as part of private sector work in Alaska, as funded by federal, state, and private entities.

#### What are the gaps in research?

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Public Infrastructure, Forestry, Agriculture and Waste , and Economic Activities

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

UA, DNR, USGS and the SDMI team

## TWG: Health and Culture

### 5.2.2.1

**Decline and migratory shifts of major subsistence species and vegetation can significantly affect a wide range of cultural, community, and economic conditions. The effects of events must be assessed after an assessment is made of existing climate related socio-economic studies. Assess socio-economic impacts of existing and emergent climate change events on culture, community wellness, subsistence, and overall economics. Assess socio-economic impacts of existing and emergent climate change events on culture, community wellness, subsistence, and overall economics.**

Unique Identifier: 80

Overarching Need

#### Why is this an issue?

The enculturation process of young hunters and gatherers through experienced adults can be severely disrupted with loss or disappearance of important subsistence species. Migration of wildlife may require extended subsistence trips, increasing costs and risks as well as substitution of expensive store bought foods.

#### Describe the scope of the research need:

The need is statewide and should be focused on key subsistence species identified in cooperation with appropriate local, regional, and statewide Alaska Native entities.

#### Policy option or recommendation:

#### What research is being done/known?

see research need

#### What are the gaps in research?

There is a dearth of climate related socio-economic impact assessments

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

UA research centers, Alaska Native regional and statewide organizations, federal and state agencies

## TWG: Health and Culture

### 5.2.2.2

Standardized ADF&G Harvest Surveys (which include considerable social, demographic and economic information in addition to household harvest per species) need to be accomplished in each of the villages designated with emergency status. Standardized ADF&G Harvest Surveys

Unique Identifier: 81

Overarching Need

**Why is this an issue?**

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Health and Culture

### 5.2.3.1

**Regional Assessments of existing social service infrastructure, staffing, budgets and delivery need to be accomplished at regional level as baseline to plan for increased demand.**

Unique Identifier: 84

Overarching Need

**Why is this an issue?**

Services are changing with the stress on rural communities that are increasing because of many factors, including climate change. Stressors include health, behavioral health, and culture with sustainability. Having accurate assessments based on research results and predictive models will allow decision makers to make plans for meeting these future needs.

**Describe the scope of the research need:**

Research includes interagency and provider assessment of level of social services available, community assessment of the adequacy of services provided, and changes in nature of illnesses, behavioral health, and culture with changing climate. Research will require social economic models that can be used to substantiate agency programs and budget needs.

**Policy option or recommendation:**

**What research is being done/known?**

Review of state, federal and native entity operating budgets and programs will provide a base upon which further research will be needed. Assess the value of interagency coordination in assuring adequacy of services given all the stressors on rural communities.

**What are the gaps in research?**

A comprehensive review of existing services, costs, and potential needs with impacts from climate change.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Health and Culture

### 5.2.3.2

**Social Impact Assessments need to be conducted at regional and community level to provide information for Section III of the NEPA process, description of the affected environment.**

Unique Identifier: 85

Overarching Need

**Why is this an issue?**

Gathering social impact assessment information will be needed to complete impact assessments and provide preferred alternatives.

**Describe the scope of the research need:**

Research is needed to develop standardized questions for social impacts in communities at risk from climate change. This will allow input to models for assessing level of risk and timeframe.

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

NOAA, MMS, USGS, BLM and USACE depending on lead on federal NEPA process. Community and Regional Native Corporations and Councils should be included to provide insight on level of risk. AK DCCED and DNR should be part of the research team.



## TWG: Health and Culture

### 5.2.3.3

**Detailed interviews and oral histories need to be conducted to provide narrative information needed to assess the impacts of climate change and the potential impacts of different forms of relocation. These interviews and oral histories need to be placed in a comprehensive library and archive.**

Unique Identifier: 86

Overarching Need

#### Why is this an issue?

As stressors impact health and culture of rural communities and indigenous people, risks to cultures and oral histories exist. Insuring comprehensive collection and archiving will preserve heritage. This is critical as heritage is being lost with aging and passing of elders.

#### Describe the scope of the research need:

Through networking with community leaders and native organizations, oral histories are preserved in a paper and electronic library.

#### Policy option or recommendation:

#### What research is being done/known?

UA maintains an active program in preserving traditional stories and language. Various native organizations continue to invest in collecting detailed interviews and oral histories.

#### What are the gaps in research?

A comprehensive archive of stories, language, and cultural artifacts and anecdotes needs to be explored for the present level of collection and probability of future success.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling  Products  Education/Outreach  Data Management  Monitoring

#### Parties involved in implementation:

UA, Native Corporations and Associations, individual communities and families

## TWG: Health and Culture

### 5.2.4.1

**1. Assess ADEC watershed contamination protection laws and source water protection program. 2. Assess effectiveness of current monitoring and surveillance programs to identify and control new pathogens or increased contaminant infiltration/runoff from**

Unique Identifier: 30

Overarching Need

**Why is this an issue?**

Increased temperatures, changing precipitation patterns, flooding, melting permafrost, and other climate change-related risks could alter the geographic range and incidence of a wide range of infectious diseases and can result in contamination of food and water sources.

**Describe the scope of the research need:**

**Policy option or recommendation:**

Augment surveillance and control programs for vector-, water-, and foodborne diseases likely to become greater threats because of climate change. Improve understanding of the potential human health impacts of climate change

**What research is being done/known?**

**What are the gaps in research?**

See the research need

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

Alaska state agencies, UA research centers, EPA, other federal agencies

## TWG: Health and Culture

### 5.2.4.2

**1. Assess sanitation and solid waste disposal infrastructure and practices at risk from flooding, melting permafrost, and other risks, or that is otherwise subject to changed conditions that significantly reduce performance in environmental health protection**

Unique Identifier: 31

Overarching Need

**Why is this an issue?**

Increased temperatures, changing precipitation patterns, flooding, melting permafrost, and other climate change-related risks could compromise sanitation and solid waste disposal infrastructure and render current practices ineffective.

**Describe the scope of the research need:**

**Policy option or recommendation:**

Assess sanitation and solid waste disposal infrastructure and practices at risk from climate and other risks that significantly reduce performance in environmental health protection. Improve understanding of the potential human health and cultural impacts of climate change

**What research is being done/known?**

**What are the gaps in research?**

See the research need

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

Alaska state agencies, UA research centers, EPA, other federal agencies

## TWG: Health and Culture

### 5.2.4.3

**Work to quantify the climate warming impact from the potential release of methane hydrates in the Arctic due to warmer sea temperatures. Study Climate Warming and Methane Hydrate Deposits**

Unique Identifier: 74

Overarching Need

**Why is this an issue?**

**Describe the scope of the research need:**

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

## TWG: Health and Culture

### 5.2.4.4

**Study the potential increase in bioavailability of persistent organic and transboundary pollutants, including pesticides, mercury, perfluorochemicals and flame retardants, which may be released from melting ice and snow and thawing soil as a result of climate warming in the arctic. Evaluate the potential health impacts on humans, ecosystems from these chemicals as well as their behavior in the food web, and develop projections as to whether these impacts and release rates can be expected to increase and to what degree in the future. Study of Climate Warming and Persistent Organic and other Pollutants.**

Unique Identifier: 75

Overarching Need

**Why is this an issue?**

Transport of pollutants and toxins with changes in atmospheric flows and oceanographic currents are impacting Alaska. Determining the extent and risk to health are a research need.

**Describe the scope of the research need:**

Monitoring changes in levels of toxins and linking to circulation models can provide insight into risks to human health

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

Monitoring protocols need to include specific toxins and transboundary pollutants

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

EPA, AK DEC, UA and native health organizations

## TWG: Health and Culture

### 5.2.4.5

**Study the interaction of increased UV exposure in the arctic on humans, animals and vegetation in conjunction with projected climate changes. Study Climate Warming and Ultra-violet Radiation.**

Unique Identifier: 77

Overarching Need

**Why is this an issue?**

Climate change can change UV exposure that may affect human health and change plant and animal distribution. This will affect culture.

**Describe the scope of the research need:**

Include UV radiation as an integral part of weather monitor stations.

Document changes in skin cancer, sunburn, and other exposure illnesses in native populations

**Policy option or recommendation:**

**What research is being done/known?**

**What are the gaps in research?**

Medical records of exposure and changes in levels of UV radiation need to be monitored

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Health and Culture

### 5.2.5.1

Unique Identifier: 33

Overarching Need

**Why is this an issue?**

Increased temperatures, changing precipitation patterns, flooding, melting permafrost, and other climate change-related risks will affect the stability of archeological sites and gravesites, requiring plans for protection or recovery.

**Describe the scope of the research need:**

**Policy option or recommendation:**

1. In cooperation with appropriate entities, complete an assessment of archaeological sites most at risk, and develop a plan for their protection or recovery. 2. Complete a statewide assessment of and response to the gravesites most at risk. Improve understanding of the potential cultural impacts of climate change

**What research is being done/known?**

**What are the gaps in research?**

See the research need

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

Alaska state agencies, UA research centers, EPA, other federal agencies

## TWG: Health and Culture

### 5.2.6.1

**1. Identify effective cooperative mechanisms to support rural communities in dealing with multiple rules and requirements. 2. In partnership with local communities, conduct an assessment of the capacity of communities to design and implement programs a**

Unique Identifier: 32

Overarching Need

**Why is this an issue?**

Increased temperatures, changing precipitation patterns, flooding, melting permafrost, and other climate change-related risks will present a wide range of challenges to rural communities that will require them to deal with multiple state and federal agencies, with overlapping and sometimes conflicting rules and regulations.

**Describe the scope of the research need:**

**Policy option or recommendation:**

Identify approaches, as well as responsible individuals, to support rural communities in dealing with complex issues requiring coordination among multiple state and federal agencies, local governments, NGOs, and others. Improve understanding of the potential health and cultural impacts of climate change

**What research is being done/known?**

**What are the gaps in research?**

See the research need

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

Alaska state agencies, UA research centers, EPA, other federal agencies



## TWG: Natural Systems

### 5.3.1.1

#### Develop better hydrology data and models statewide.

Unique Identifier: 53

Overarching Need

#### Why is this an issue?

Trend data and global climate models indicate a warmer and sometimes wetter climate for Alaska in the future. Planning for river navigation, flood hazard estimation, and cost-efficient engineering of public roads, culverts, bridges, water, and wastewater systems require accurate estimation of water flow volume and seasonality. Historic data and existing statewide coverage are inadequate for present and future needs.

#### Describe the scope of the research need:

Improve the currently available hydrology (NHD) dataset so that accurate modeling can be accomplished to understand and develop forecasts to anticipate changing surface water bodies, surface and subsurface flow (volume, timing, and locations), composition (nutrients, sediment) in priority areas. Gather data on hydrologic parameters throughout the state to establish baselines, so the effects of climate change on these parameters (e.g., precipitation, snowpack, and streamflow) can be evaluated. Improve gauging and monitoring to determine water supply and seasonality.

#### Policy option or recommendation:

NS-3 Manage climate change impacts on watersheds and in-stream flows.

#### What research is being done/known?

USGS has a network of stream gages and has developed a list of locations for possible expansion in AK. The NSSI has been investigating remote sensing technologies for detecting flows.

#### What are the gaps in research?

Stream gage coverage is insufficient for accurate modeling in much of the state.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Overarching climate change information need.

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

USGS. IATCA

## TWG: Natural Systems

### 5.3.1.10

Assess, model, and monitor coastal impacts of changes to sea level and ice.

Unique Identifier: 40

Overarching Need

#### Why is this an issue?

Coastal erosion is increasing with reduced sea ice cover and thawing permafrost. Rapid erosion is exposing buried infrastructure, undercutting road and building foundations, and destroying natural and cultural resources.

#### Describe the scope of the research need:

Project, map and monitor coastal erosion impacts in the context of sea level rise, coastal uplift, reduced sea ice, subsidence from permafrost thaw, tides, storms, short-term (El Nino-type) components. Develop detailed sea level change models, projections, and impact maps; increase monitoring of coastal erosion in the context of sea level rise, coastal uplift, sea ice loss, subsidence, and permafrost thaw; and increase monitoring for real-time and forecasts of ocean conditions (winds, waves, sea ice, currents, temperature, salinity, pH, etc.). Assess coastal substrate/sediment susceptibility to erosion (rock, ice, soil). Develop detailed sea level change models, projections, and impact maps. Improve monitoring of key climate change indicators & effects. Monitor coastal erosion in context of changing sea level rise, coastal uplift, and sea ice loss. Improved monitoring and forecasting of sea level rise will inform modeling and forecasting of impacts. Increase monitoring of coastal erosion and storm impacts.

#### Policy option or recommendation:

Overarching climate change information need

#### What research is being done/known?

National Water Level Observation Network sites provide data for trends (<http://co-ops.nos.noaa.gov/sltrends/sltrends.shtml>). Numerous modeling efforts are underway relative to sea level, sea ice and permafrost. Coastal erosion has recently been quantified in several areas of the North Slope and NW Alaska.

#### What are the gaps in research?

Local isostatic rebound needs to be factored into models of sea level rise in formerly glaciated areas. DEMs are lacking for accurate coastline and inundation modeling. Need National Water Level Observation Network stations along west and north coasts; need technology developed to get these measurements in iced areas.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

AOOS, AGDC, NOAA, USGS, UAF, Land management agencies

## TWG: Natural Systems

### 5.3.1.11

#### Down-scaled climate models

Unique Identifier: 39

Overarching Need

#### Why is this an issue?

Global Climate Model data is too coarse to inform communities and local resource managers about probable changes at local levels.

#### Describe the scope of the research need:

Develop projections of future climate on a local scale for communities and land management units throughout Alaska, using scaled-down global climate model data and appropriate Alaska datasets (e.g., PRISM).

#### Policy option or recommendation:

Overarching climate change research need.

#### What research is being done/known?

SNAP and others are actively developing downscaled model data. Model outputs are available for most communities and land management units across Alaska.

#### What are the gaps in research?

Output needs to be generated for additional areas. Models need continual refinement to reflect new research findings and to correct assumptions. Expand these downscaling efforts to ocean environment (just starting in the Chukchi).

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

UAF SNAP, USGS, NOAA, FS

## TWG: Natural Systems

### 5.3.1.12

#### Coordinated climate and ecosystem monitoring.

Unique Identifier: 38

Overarching Need

#### Why is this an issue?

Long-term datasets with reliable indicators and across large geographic areas (regional and continental scale) are essential to determine climate and resource condition trends.

#### Describe the scope of the research need:

Develop a set of reliable physical and biological indicators of climate change (including species and phenology) and related community impacts, to identify the most effective ways to implement short-, mid-, and long-term status and trend monitoring across broad areas and multiple land management units. Consider low-tech monitoring techniques (and its adequacy), local data observations with less than full weather service standards, satellite imaging, new sensors with communications systems, vehicles as probes.

#### Policy option or recommendation:

#### What research is being done/known?

Many agencies already have long-term ecological research and monitoring programs that could contribute data, but comparability of observations of different variables collected by different methods is an issue. Many nongovernmental scientists (with universities, private companies, and corporations) also have environmental monitoring data that could contribute to overall understanding if it were to be made public.

#### What are the gaps in research?

Identification and adoption of a set of common physical and biological indicators across the state, nation, and worldwide is an early need for comparability of monitoring data. Intellectual property and other issues interfere with sharing of data.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

NPS, NOAA, USGS, EPA, AFS, ACCAP, AOOS, SAON, NEON

## TWG: Natural Systems

### 5.3.1.13

**Determine appropriate indicators of climate change and community impacts. Improve monitoring of key climate change indicators & effects, with emphasis on effects with large societal impacts. Monitor climate change indicators and their societal impacts**

Unique Identifier: 1

Overarching Need

#### Why is this an issue?

Improved monitoring of key climate change indicators relevant to Alaska will allow for tracking of climate change effects and will contribute data to modeling and assessments. Monitoring of indicators of community impacts related to climate change will inform assessments of societal impacts and support planning and adaptation.

#### Describe the scope of the research need:

1. Identification of appropriate indicators of climate change and of community impacts.
2. Development and implementation of routine, on-going monitoring of indicators.
3. Development and improvement of modeling capabilities for indicator prediction.
4. Development of information and products for public use.

#### Policy option or recommendation:

Overarching climate change information need

#### What research is being done/known?

Relevant data has been collected by agency (ADF&G, Division of Forestry, USFWS), tribal managers (e.g., North Slope Department of Wildlife and Council of Athabaskan Tribal Governments) and University scientists (e.g., Long-term Ecological Research Sites) Examples of reports cards include:- Arctic Report Cards (<http://www.arctic.noaa.gov/reportcard/index.html>) - Sea Ice Outlook (NOAA/PMEL)

#### What are the gaps in research?

Assessment of observed responses to determine the most sensitive indicators, that should be monitored and reported on. Gaps in monitoring of key climate change indicators may include: - ice type need to increase the density of climate change data sites - gaps in climate reference network (only 4 of 33 sites in AK installed)- monitoring trends in marine mammal species abundance and distribution

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

Alaska state agencies; University of Alaska; EPA, NOAA and other federal agencies

## TWG: Natural Systems

### 5.3.1.14

#### Protect community water supplies and instream flows.

Unique Identifier: 26

Overarching Need

#### Why is this an issue?

Freshwater runoff from snow and icemelt is a major source of drinking water for communities. Adequacy of future supplies cannot be assumed with climate change.

#### Describe the scope of the research need:

Identify water needs, supplies, and rights of Alaskan communities, domestic and commercial and ecological. Develop water supply scenarios to better understand the broad range of impacts of climate change on fresh water quantity, flow, seasonality and quality in Alaska. Assess community's current and future water needs. Assess water rights for community potable water supplies, "subsistence priority", and water fish and wildlife habitat. Assess sustainability of water flows used for hydropower and aquifer recharge, and in-stream flows. Identify areas where future water needs are likely to be insufficient, using assessment tools such as the Arctic Water Resources Vulnerability Index (AWRVI), and review appropriateness of long-term water management strategies for these regions.

#### Policy option or recommendation:

NS-3. Manage climate change impacts on watersheds and in-stream flows.

NS-6. Prepare for adaptive management of fish and wildlife.

#### What research is being done/known?

USGS and others operate river gages

#### What are the gaps in research?

Gather data on hydrologic parameters (e.g., precipitation, snowpack, streamflow) throughout the state to establish baselines, so effects of climate change on these parameters can be evaluated. Conduct legal analysis of water rights.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Health and Culture.

Public Infrastructure

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

ADF&G,ADNR,USGS,NOAA

## TWG: Natural Systems

### 5.3.1.15

**Expand research and monitoring of contaminants deposition and bioavailability under changing climate.**

Unique Identifier: 178

Overarching Need

**Why is this an issue?**

Contaminants can affect health and survival of fish, wildlife, and people.

**Describe the scope of the research need:**

Include consideration of Persistent Organic Pollutants (POPs) and mercury that are produced in other areas (by wildland fire, coal burning, etc.) and precipitate in arctic environments by global air circulation. Also consider potential for spread of contaminants result from permafrost thaw and erosion in historically contaminated areas (e.g., military dumps, legacy wells).

**Policy option or recommendation:**

**What research is being done/known?**

EPA and NPS have recently completed the Western Airborne Contaminants Assessment Program that had both expected and unexpected results about contaminants in remote areas of Alaska. The State has assessed contaminants in fisheries and subsistence foods. DOD has cleaned up several known contaminant sites.

**What are the gaps in research?**

Extent and locations of contaminated historic dumps are not fully delineated. Effects of climate change on bioavailability and biomagnifications, ecological, and human effects, are incompletely understood.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Overarching climate change information need

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

EPA, USGS, DOD, DNR, NPS

## TWG: Natural Systems

5.3.1.16

### Develop landcover base maps statewide

Unique Identifier: 183

Overarching Need

#### Why is this an issue?

Understanding changes in landcover types are critical to assessments related to fire, forestry, wildlife, fisheries, etc. GIS and maps are basic tools needed for many analyses.

#### Describe the scope of the research need:

Need 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.

#### Policy option or recommendation:

Overarching climate change information need.

#### What research is being done/known?

Numerous mapping programs are underway, but purposes, coverage, scale, and details vary. GINA is compiling base maps for the North Slope

#### What are the gaps in research?

Currently only portions of the state have this information available.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

USGS, UAF GINA and all land management agencies



## TWG: Natural Systems

5.3.1.17

### Assess communications strategies for climate change information.

Unique Identifier: 186

Overarching Need

#### Why is this an issue?

Poorly communicated information about climate change can cause more harm than good.

#### Describe the scope of the research need:

Determine the most effective information sources for communities to receive accurate and complete information about climate change.

#### Policy option or recommendation:

#### What research is being done/known?

The Alaska Immediate-Action Working Group has initiated a mini-grant program with six Alaskan communities in immediate risk of climate-induced erosion that demonstrates the feasibility of such a program.

#### What are the gaps in research?

Avoid or counter counterproductive “scary” and sensational information, as was sometimes the case information about avian influenza.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

UAF Cooperative Extension Service, ASG MAP, NPS, FS, and FWS resource interpretation programs, teacher education, curriculum-based materials, on the ground.

## TWG: Natural Systems

### 5.3.1.2

#### Identify permafrost thaw hazards and incorporate into engineering guidelines.

Unique Identifier: 54

Overarching Need

##### Why is this an issue?

The IPCC predicts widespread permafrost thaw across the Northern Hemisphere in this century. Cracking roads and subsiding building foundations are common in some areas where permafrost thaw is accelerating. Landslides and mudflows are also occurring on thawing wet hill slopes, sometimes blocking roads, rivers, and degrading fish habitats. Engineers, builders, and planners need accurate maps and forecasts for planning.

##### Describe the scope of the research need:

Permafrost thaw. Identify trends and trajectories in active layer (seasonal thaw zone) depth and permafrost zones (i.e., continuous, discontinuous), and thaw hazards, through modeling, soil surveys, and studies of permafrost degradation. Include analysis of geotechnical data collected for construction projects, drill logs, and collect data from monitoring systems that have already been installed under many Alaska highways. Include coastal erosion vulnerability mapping, as permafrost stability is a major factor. Incorporate data into an updated published environmental atlas for engineers.

##### Policy option or recommendation:

##### What research is being done/known?

UAF has several permafrost and active layer monitoring programs underway. CRREL has incorporated some newer information into the GIS-based Alaska Engineering Design Information System (AEDIS).

##### What are the gaps in research?

Permafrost and active layer mapping is incomplete across much of the state and several potentially useful data streams remain uncollected or unanalyzed (e.g., geotechnical soil test data, highway thermister networks). Models are in development but require soils mapping for precision and monitoring data for verification. Data published in the Environmental Atlas of Alaska is long out of date (1978), and there appear to be liability concerns preventing engineers from widely adopting unpublished AEDIS data.

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

##### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

##### Parties involved in implementation:

UAF, ACCAP, NRCS, ADOT, NSF

## TWG: Natural Systems

### 5.3.1.3

#### Identify and research regulatory and policy issues.

Unique Identifier: 57

Overarching Need

#### Why is this an issue?

Many of the laws, policies, and regulations that direct management of public and private lands and waters are premised on stable climates, or at least on the ability to envision future conditions (e.g., ANILCA, ESA, CFR, CZMA). What will be the standard of successful resource management in a changing future? Can state and federal agencies preserve the unique and special values that are identified in legislation in the face of climate change? How will they develop adaptation strategies for fish, animals and plants when their natural climate zones move beyond management units, state and national borders?

#### Describe the scope of the research need:

Identify inconsistencies in laws, regulations and policies that limit the abilities of the State, federal, Native and local agencies, businesses and individuals to effectively address and manage climate change impacts on natural resources.

#### Policy option or recommendation:

#### What research is being done/known?

Several DOI agencies have begun identifying laws, regulations, and policies that may limit their ability to address climate change issues. UAA law professor Julie Lurman Joly has researched regulatory barriers to facilitated migration of at-risk species into more favorable habitats.

#### What are the gaps in research?

Laws, regulations, and policies need to be evaluated relative to potential future scenarios, and with legal advice to determine whether there is sufficient flexibility for dealing with climate changes or whether changes are appropriate.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Overarching climate change information need

#### Research category/type:

Modeling  Products  Education/Outreach  Data Management  Monitoring

#### Parties involved in implementation:

ACCAP, Federal and State regulatory agencies, with legal advice from agency solicitors

## TWG: Natural Systems

### 5.3.1.4

#### Implement local climate change scenario planning workshops in communities across Alaska (coastal, arctic, interior, etc.).

Unique Identifier: 58

Overarching Need

##### Why is this an issue?

Alaskan's are receiving conflicting, sometimes sensational and frightening information about climate change from many sources. However, few communities really understand what changes to expect in their area, or how fast to expect them. As heard at the ACTEM climate change session, communities need updated mapping, photographs, and projections of environmental changes to be able to effectively plan for their adaptation to climate change.

##### Describe the scope of the research need:

Improve accuracy and currency of mapping and aerial photography near communities, to assist communities with planning for adaptation to climate change. Apply models and develop scenarios of changes in climate, environmental hazards (erosion, wildfire, flooding) to facilitate future community planning. Workshops would include discussion of potential effects under a probable range of future climate scenarios, with discussion of how physical, biological, cultural, and social changes associated with rapid climate change would affect communities and resources.

##### Policy option or recommendation:

##### What research is being done/known?

University of Alaska is developing remote sensing and photographic products (Geographic Information Network of Alaska - GINA) and scenarios of future environment and risks (Scenarios Network for Alaska Planning - SNAP)

##### What are the gaps in research?

Fill critical gaps in photography, maps and scenarios. Improve accessibility of information to agencies and communities.

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

##### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

##### Parties involved in implementation:

SNAP, AOOS, GINA, ACCAP. Coordinate information and activities with federal agencies (e.g., USGS, NOAA, NASA) and Native organizations.

## TWG: Natural Systems

### 5.3.1.5

#### Hazards identification and assessments.

Unique Identifier: 56

Overarching Need

#### Why is this an issue?

#### Describe the scope of the research need:

Identify and research specific hazards, mitigation measures, and response capacity needed for dealing with effects of rapid climate changes on: fire regimes and forest fuel hazards, physical hazards (glacial outbursts and river flooding, surging glaciers, avalanches, landslides, ground failures, solifluction, erosion, inundation, subsidence), invasive species (plants, animals, pests and diseases), species habitat loss and fragmentation, and vulnerabilities to spread of contaminants resulting from persistent organic pollutants (POPS) and permafrost thaw.

#### Policy option or recommendation:

#### What research is being done/known?

USGS, CCREL, and UAF researchers are researching and monitoring selected hazards (e.g., Hubbard and Tweedmuir glaciers), and other researchers and resource managers are dealing with recognized hazards, where possible.

#### What are the gaps in research?

A comprehensive and specific assessment, to identify specific risks and locations, is lacking. Southeast Alaska is a priority area due to rapid glacial retreat and unstable soils.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

USGS, NOAA, CG, EPA, multiple federal and state agencies

## TWG: Natural Systems

### 5.3.1.6

#### Data integration

Unique Identifier: 50

 Overarching Need**Why is this an issue?**

Decisions are being made without benefit of available data and redundant research activities are started for lack of access to existing data.

**Describe the scope of the research need:**

Expand data integration and collaboration to facilitate increased access to information and ensure inter-operability of multiple data management systems.

**Policy option or recommendation:****What research is being done/known?**

Leslie Holland-Bartels of USGS has assembled a group to integrate applications with several public databases

**What are the gaps in research?**

Unpublished data held by federal and state agencies, academic scientists, and businesses is still not widely shared.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?****Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

USGS, AOOS, UAF-GINA, NPRB, NSSI, ADFG

## TWG: Natural Systems

### 5.3.1.7

#### Changes to vital ecosystem services

Unique Identifier: 45

Overarching Need

#### Why is this an issue?

##### Describe the scope of the research need:

Research potential impacts/ramifications of the changes to all affected resource types, including: atmosphere, cryosphere, hydrosphere, biosphere, and lithosphere the ecosystem services that they provide, and the societal impacts of these changes.

##### Policy option or recommendation:

- NS-2. Review and modify Alaska's wildland fire policy and programs.
- NS-3. Manage climate change impacts on watersheds and in-stream flows.
- NS-4. Reduce introduction and spread of invasive species in the context of climate change.
- NS-6. Prepare for adaptive management of fish and wildlife.
- NS-7. Develop capacity in new forestry and wood biomass opportunities.

##### What research is being done/known?

Research, monitoring, and modeling is underway to determine status and trends and to forecast changes in some topics. Fire modeling is underway to anticipate changes in fire behavior.

##### What are the gaps in research?

The cascading effects of large scale environmental change need to be considered. What are the consequences of ecosystem changes to vital natural services and economic resources, such as water supply, air quality, ocean fisheries, etc. How will large scale changes in the boreal forest affect other factors? What are the potential tipping points, where vital services are no longer being provided (e.g. fish population crash).

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

##### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

##### Parties involved in implementation:

UAF, ACCAP, NSF ADF&G, USFWS, DOF

## TWG: Natural Systems

### 5.3.1.8

**Geospatial data needs, aerial photography, digital elevation models (DEM), and remote sensing data.**

Unique Identifier: 42

Overarching Need

**Why is this an issue?**

There are highly important specific early needs to facilitate other data gathering efforts. For example, accurately represented coastal land elevations are needed for modeling how sea level rise will affect low lying coastal areas.

**Describe the scope of the research need:**

Improve the currency and accuracy of aerial photography, DEMs, and remote sensing data available statewide for community and agency use in planning adaptation strategies for climate change. Ensure that new mapping meets needs of coastal and ocean community, as well as terrestrial needs.

**Policy option or recommendation:**

**What research is being done/known?**

Multiple agencies are acquiring imagery for particular purposes, but more coordination could result in better coverage and detail, potentially with less redundancy and lower overall cost.

**What are the gaps in research?**

Much of Alaska's area has not been mapped recently or to modern standards of accuracy. DEMs are required for appropriate orthorectification of imagery and to ensure an adequate base map is available for other resource mapping and analysis, including coastlines, fire, and wildlife.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

AGDC



## TWG: Natural Systems

### 5.3.1.9

#### Coastal mapping and shoreline characterization.

Unique Identifier: 41

Overarching Need

#### Why is this an issue?

Conduct an Alaska Shoreline Impact Assessment Project to establish a baseline of data on the existing biotic coastal resources and the projected impacts of sea level rise (including effects of tides, weather and short-term [El Nino-type] components). Characterize Alaska's coastal shoreline and coastal resources (e.g., NOAA ShoreZone), geomorphology, biology, cultural sites.

#### Describe the scope of the research need:

Complete baseline characterization of Alaska's coastlines (i.e., NOAA ShoreZone, geomorphology, biology, cultural sites) to enable coastal impact forecasting, scenario planning, monitoring, trend analysis, and spill response following shipping accidents, which are expected to increase as sea ice diminishes in the Northwest Passage.

#### Policy option or recommendation:

NS 6 Fish & Wildlife Management:(6.2) Coordinate state & federal management to adapt to mitigate climate change effects on species, when feasible.

#### What research is being done/known?

Much of Southeast and Southwest Alaska has been mapped through videography.

#### What are the gaps in research?

Northwest Alaska and some parts of Southeast (e.g., inner Glacier Bay) remain to be mapped. Mapping will require accurate DEM's for vertical control shoreline. Combine orthophoto mosaic data and oblique (ShoreZone) dataset to be able to use both. Access newly declassified defense imagery.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling  Products  Education/Outreach  Data Management  Monitoring

#### Parties involved in implementation:

AGDC, NOAA, USGS, NPS

## TWG: Natural Systems

### 5.3.2.1

**Synthesize current information about climate change impacts on fisheries impacts and assess its reliability and degree of uncertainty. Conduct fisheries ecological modeling.**

Unique Identifier: 180

Overarching Need

#### Why is this an issue?

##### Describe the scope of the research need:

Understand how productivity of coastal and estuarine systems may change and species composition shift in response to environmental changes and resource use. One connection may be to better understand the lack of recovery for herring, crab and shrimp fisheries along the Gulf of Alaska.

##### Policy option or recommendation:

NS-1. Incorporate climate change into commercial fisheries management and assist fishing communities and users in adaptation.

##### What research is being done/known?

Considerable research has been conducted on marine “regime change” due to “El Nino/La Nina” effects, that may be informative to modeling effects of long-term climate change.

##### What are the gaps in research?

Questions about some historic population shifts remain unanswered. Fisheries status and trend data is incomplete.

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

##### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

##### Parties involved in implementation:

UAF, NOAA/NMFS, NPRB, EVOSTC, USGS, NCCSP. Partnership between federal, state and university coastal labs and researchers. (John Piatt, Anne Hollowed)

## TWG: Natural Systems

### 5.3.2.2

#### Arctic Ocean fisheries assessments.

Unique Identifier: 181

Overarching Need

#### Why is this an issue?

Fisheries population shifts are occurring due to ecological change, and ship access is increasing with reduced sea ice. Commercial fishing in new areas would have uncertain effects to previously unaffected populations

#### Describe the scope of the research need:

Determine abundance and vulnerability of Arctic Ocean fish species, potential bycatch, and critical dependencies (e.g., marine mammals).

#### Policy option or recommendation:

NS-1. Incorporate climate change into commercial fisheries management and assist fishing communities and users in adaptation.

#### What research is being done/known?

Basic research has been completed on many Arctic species by academic researchers.

#### What are the gaps in research?

Status and trends of species with commercial potential is largely undetermined. Vulnerabilities of non-target species have not been determined.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

NOAA/NMFS, UAF, MMS

## TWG: Natural Systems

### 5.3.2.3

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

Unique Identifier: 13

Overarching Need

#### Why is this an issue?

Improved monitoring and forecasting of changing ocean conditions will inform modeling and forecasting of related biotic changes, as well as inform marine-based human uses. Physical data is needed to predict and explain biological responses. Impacts of freshwater from glacial melt on marine ecosystem is needed to improve understanding of effects of climate change on marine ecosystems. Water temperature increases are correlated with oceanic regime changes and with locally reduced salmon returns and increased fish disease (e.g., Yukon River). Ocean acidification of the magnitude that has been occurring is expected to have significant impacts to food webs, and certain species (e.g. corals, shellfish).

#### Describe the scope of the research need:

Monitor and model potential change for ocean currents, temperature, salinity, and acidification. Temperature data has been collected for a long time at many tide stations (but we only have 2 tide stations in the Arctic), but the data is sparse across the Arctic, and oceanographic changes will need salinity data to understand what climate aspects are driving, changing oceanographic conditions. Add conductivity sensors to tide stations. Institute an ocean acidification monitoring program.

#### Policy option or recommendation:

NS-1. Incorporate climate change into commercial fisheries management and assist fishing communities and users in adaptation.

#### What research is being done/known?

AOOS is developing a cooperative network of observing stations.

#### What are the gaps in research?

Oceanic and coastal seawater monitoring remains limited.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

AOOS

## TWG: Natural Systems

### 5.3.2.4

#### Fisheries policy considerations.

Unique Identifier: 179

 Overarching Need**Why is this an issue?****Describe the scope of the research need:**

Research what other countries, U.S. federal agencies and other states are doing to incorporate climate change considerations into commercial fishing policies, management, and other adaptations. Assess what is appropriate to Alaska conditions.

**Policy option or recommendation:**

NS-1. Incorporate climate change into commercial fisheries management and assist fishing communities and users in adaptation.

**What research is being done/known?****What are the gaps in research?****If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?****Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

NMFS, NPRB, ADFG.

## TWG: Natural Systems

### 5.3.2.5

**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.**

Unique Identifier: 14

Overarching Need

#### Why is this an issue?

Broad scale changes in fisheries species abundance and distribution are expected. Changing stream/lake biochemistry may drive freshwater ecosystem change and changes in abundance and distribution of species of commercial or subsistence importance (as well as other effects.) Monitoring is essential to inform policy, management, and users' decisions. Data will support modeling and forecasting. The Anadromous Waters Catalog is the key tool for documenting freshwaters important to anadromous fish and providing protection for this habitat.

#### Describe the scope of the research need:

Establish long-term monitoring to document changes and trends in fish species abundance and distribution. Update the Anadromous Waters Catalog to document and protect waters that support anadromous fish. Research stream/lake biochemistry in order to improve understanding of effects of climate change on freshwater ecosystems. Increase research on stream/lake biochemistry impacts due to land cover conversion, permafrost degradation, and changing precipitation regimes within watersheds. (Contact Bruce Peterson, Woods Hole Marine Biological Lab, <http://ecosystems.mbl.edu/Tide/contact/peterson.htm>) Improve information available to fishery managers, participants in commercial and subsistence fisheries, and fishing communities. Monitor trends in marine and freshwater fish species abundance and distribution.

#### Policy option or recommendation:

NS-1. Incorporate climate change into commercial fisheries management and assist fishing communities and users in adaptation. NS-6. Prepare for adaptive management of fish and wildlife.

#### What research is being done/known?

Salmon runs are monitored relative to escapement goals.

#### What are the gaps in research?

Marine fisheries monitoring is limited. Many streams are also not monitored regularly. Effects of permafrost thaw are largely undetermined

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

ADFG, NMFS, AOOS, ACCAP

## TWG: Natural Systems

### 5.3.2.6

#### Consider need for protected fish conservation areas. Evaluate tools for fish species conservation

Unique Identifier: 15

Overarching Need

##### Why is this an issue?

Expanding fisheries pressure can deplete target and bycatch populations and degrade habitats. Reduced sea ice increases the likelihood of increased fishing pressure in Arctic waters.

##### Describe the scope of the research need:

Research potential need for protected areas to ensure sustainability of species important to commercial or subsistence fisheries.

##### Policy option or recommendation:

NS-1. Incorporate climate change into commercial fisheries management and assist fishing communities and users in adaptation.

##### What research is being done/known?

A growing body of research shows significant benefits from establishment of marine protected areas. However, such decisions are not always made on firm scientific basis relative to needs of commercially important species.

##### What are the gaps in research?

Species status and trend data, and assessments of habitat quality and fishing pressure would greatly help.

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

##### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

##### Parties involved in implementation:

ADFG, NOAA, NPS, USGS, UAF

## TWG: Natural Systems

### 5.3.3.1

#### Fire and fuel modeling.

Unique Identifier: 44

Overarching Need

#### Why is this an issue?

Fire hazards are expected to increase with rising air temperature.

#### Describe the scope of the research need:

Conduct detailed modeling (including hind- and fore-casting) of wildland fire frequency, intensity, and areas, including likely effects on principle landcover types (e.g., conifers, deciduous, grass, tundra). Modeling is needed to assess future fire dynamics under a suite of potential future climate scenarios. What would happen under an increased fire protection strategy scenario as well as the current management action. Fine-scaled projections of future fire regime would benefit communities in preparing their Community Wildfire Protection Plans.

#### Policy option or recommendation:

NS-2. Review and modify Alaska's wildland fire policy and programs.

#### What research is being done/known?

Modeling is underway by UAF SNAP with the AFS. Other published models are also available (e.g., Bachelet et al. 2005)

#### What are the gaps in research?

Modeling is more refined for coniferous forests than for tundra or grassland.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

UAF SNAP, ACCAP, JFSP



## TWG: Natural Systems

### 5.3.3.2

**Review and coordinate wildfire policies with Canadian counterparts. Determine efficacy and ecological effects of different fire management policies.**

Unique Identifier: 10

Overarching Need

**Why is this an issue?**

Current wildland policy is not Full Suppression. Research would inform policy makers about potential positive and negative effects to wildlife habitat of allowing wildland fires to burn.

**Describe the scope of the research need:**

Determine if mechanical fuel treatments are achieving the desired condition class change in the fuel type. Determine best landscape “mosaic” of burned and unburned areas for wildlife habitat, not just by landcover type, and incorporate information into policies. Monitor and research tundra fire effects, including the impacts of fire on winter caribou range and changes in vegetation patterns and succession caused by fire. This will require improved remote sensing of burn severity and depth of fire (e.g., deep fires on Yukon Flats).

**Policy option or recommendation:**

NS-2. Review and modify Alaska’s wildland fire policy and programs.

**What research is being done/known?**

**What are the gaps in research?**

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

## TWG: Natural Systems

### 5.3.3.3

#### Tundra fire mitigation measures.

Unique Identifier: 184

Overarching Need

#### Why is this an issue?

Tundra fires are expected to increase as shrubs move into tundra and as soils dry from climate warming. Remote communities have limited fire fighting capacity.

#### Describe the scope of the research need:

Evaluate mitigation strategies for communities in tundra-dominated ecosystems to create fuel breaks at the wildland interface (e.g., gravel perimeter road around community) to reduce risk of wildland fire spreading among structures, as well as spread of fire from communities into wildlands (e.g., escaped trash fires at dumps).

#### Policy option or recommendation:

NS-2. Review and modify Alaska's wildland fire policy and programs.

#### What research is being done/known?

Considerable experience has been gained on managing wildland fire – urban interface in other environments. UAF SNAP is modeling future fire scenarios.

#### What are the gaps in research?

Tundra and permafrost respond differently to fire and other ground disturbing activities than other environments. Modeling of tundra fire is less developed than for coniferous forests.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Health and Culture

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

AFS, JFSP, affected communities, UAF SNAP

## TWG: Natural Systems

### 5.3.4.1

**Identify and develop methods to assess and control invasive and irruptive plant, animal, and diseases likely to become established, expand their range, or be intentionally introduced in Alaska due to climate change.**

Unique Identifier: 52

Overarching Need

#### Why is this an issue?

Established terrestrial, aquatic, and marine species are shifting north into Alaska, while other species are also arriving from other seas and continents. Some new arrivals will compete with current species or carry parasites and diseases previously not present in Alaska.

#### Describe the scope of the research need:

Identify, model, and monitor and research specific risks to native species and ecosystems due to climate-driven expansion of invasive plant, animal, disease and pest species (terrestrial, freshwater, and marine), including potential transmission routes, trigger points, and conditions affecting establishment. Irruptive native pests that, under conditions of climate change, may expand rapidly and have comparable effects to invasive non-native species (e.g., bark beetles, "rocksnot" diatom) should also be considered. Identify mechanisms of long-dispersal of plants and animals in order to create barriers for invasives, while not interfering with movement of native species. Expansion into warmer and dryer areas where native species are stressed by climate change needs to be modeled, so that control measures can be designed and implemented where appropriate. Identify new species with high risk of arrival and spread. Assess laws and policies affecting introduction, spread, and control of invasive species. Support development of "best methods" guidelines for preventing spread of invasive species. Assess existing ballast water treatment and hull cleaning technologies for application in Alaska. Assess effectiveness of practices for new-roads maintenance equipment, schedules and methods in reducing the spread of invasive plants. Develop capacity for commercial production of native plants materials from local sources for revegetation projects to reduce the probability of exotic species becoming established following ground disturbance (construction, fire, etc.). Research benefits, ecological niche, potential invasiveness of potential "new" introduced species, including agricultural, horticultural, and forest vegetation better adapted to a warming climate. Public outreach and education are needed to reduce introductions in fishing areas and along recreational and subsistence trails. Definitions: An "invasive species" is a species that is non-native (alien or exotic) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. "Introduction" means the intentional or unintentional escape, release, dissemination, or placement of a species into an ecosystem as a result of human activity (Executive Order 13112).

#### Policy option or recommendation:

NS-4. Reduce introduction and spread of invasive species in the context of climate change.

#### What research is being done/known?

Alaska's invasive species plans address known risks for weeds, invasive species, and rodents, and are mostly focused on species with demonstrated high invasiveness through experience here or elsewhere: <http://www.adfg.state.ak.us/special/invasive/invasive.php> Criteria for ranking invasiveness have been developed for plants. Modeling has shown road, railroad, and trail corridors to be plant transmission zones, especially where they cross rivers and streams. Ballast water and recreational boating are among known aquatic hazards.

#### What are the gaps in research?

Disease organisms with high risks to agriculture and humans are largely recognized in the agricultural and human health fields, but are not fully considered in the context of climate change.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Forestry, Agriculture & Waste, Health & Culture

#### Research category/type:

Modeling  Products  Education/Outreach  Data Management  Monitoring

#### Parties involved in implementation:

USGS, UAF, NMFS, CNIPM, ASG, ACCAP, FS, NRCS

## TWG: Natural Systems

### 5.3.4.1

Provide effective monitoring, forecasting and response to marine invasive species

Unique Identifier: 12

Overarching Need

#### Why is this an issue?

The number and distribution of invasive species is expanding in Alaska. Invasive species frequently outcompete valued native species and cause severe economic and ecological damage.

#### Describe the scope of the research need:

Monitor distribution and spread of marine species, Atlantic salmon, Spartina, green crabs, and invasive tunicates in Alaskan coastal waters. Develop and implement statewide monitoring program for disease irruptions and invasive species that affect fish and shellfish, including PSP, Vibrio and HAB

#### Policy option or recommendation:

NS 4 Invasive Species: implement statewide strategic plan of action to address invasives and erupted plants, insects, pathogens and marine invasivess.

#### What research is being done/known?

Information on the spread of marine invasive species in Alaska is largely localized or incidental.

#### What are the gaps in research?

Broad and consistent monitoring of marine invasive species, in time to take action, is largely lacking.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

DEC, State Public Health Dept., EPA, NOAA, FDA

## TWG: Natural Systems

### 5.3.5.1

#### Better wildlife and fisheries populations and harvest rate data.

Unique Identifier: 51

Overarching Need

#### Why is this an issue?

Alaska's terrestrial, aquatic and marine ecosystems are changing, as are the natural habitats required by wildlife and fishery species. Scientists expect rapid change in some areas as trees and shrubs expand into tundra, fires reduce the size and extent of coniferous forests, and permafrost thawing and thermokarst change the distribution and size of wetlands. Alaska's rural population, tourism industry, and many businesses depend on healthy wildlife and fish populations for food and income. Accurate monitoring data and forecasts are needed to inform decision makers about resource management needs and options, including changes to laws, policies, and regulations.

#### Describe the scope of the research need:

Expand long-term monitoring, modeling, and use of traditional and local knowledge to understand how species abundance and distribution are changing. Develop criteria for triggering investigation of unexpected population changes. Develop projections of future changes to potential wildlife habitat that are likely to result from climate-driven changes to landcover (vegetation), wildfire frequency and intensity, and permafrost thaw, etc. Consider fire impacts from subsistence, historic, and TEK perspectives for holistically modeling fire effects. Prioritize subsistence and rare species based on current assessments (ADF&G wildlife conservation plan). Increase State/Federal cooperation in joint wildlife surveys, monitoring, and data management, especially for species with large home ranges (e.g., WACH WG, KBBPMG). Continue community/guild surveys (breeding bird, Christmas bird count) and available game surveys. Integrate High Latitude Ecological Survey ([www.HLEO.org](http://www.HLEO.org)) with citizen reporting network (e.g., CARMA <http://www.rangifer.net/carma/>).

#### Policy option or recommendation:

NS 6 Fish & Wildlife Management:(6.2) Coordinate state & federal management to adapt to mitigate climate change effects on species, when feasible.

#### What research is being done/known?

ADFG and several federal agencies have ongoing population monitoring programs for many species. USGS, NPS, and FWS have implemented WildCast to model landcover and potential habitat change north of the Yukon River. Community harvest surveys that are conducted under ADFG protocols document historic and current consumption trends in many communities.

#### What are the gaps in research?

Frequency and precision of monitoring is insufficient to accurately estimate population status and trends for some species. Limited data sharing between State and federal agencies remains a constraint. Modeling of climate change impacts to wildlife is just beginning. Community harvest surveys are missing or out-of-date for many communities.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Health & Culture, Economic Activities

#### Research category/type:

Modeling  Products  Education/Outreach  Data Management  Monitoring

#### Parties involved in implementation:

ADFG, FWS, NPS, NMFS, WACH WG, KBBPMG

## TWG: Natural Systems

### 5.3.5.2

**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.**

Unique Identifier: 16

Overarching Need

#### Why is this an issue?

Climate change will have cascading effects on multiple physical, biological, social, and cultural resources. However, the scope and scale of those effects is largely undetermined.

#### Describe the scope of the research need:

Assess vulnerability of fish and wildlife ecosystems. Complete a vulnerability assessment to identify specific species, habitats, landscapes, ecosystem functions, and cultural resources that may be most sensitive to climate change, in order to prioritize allocation of scarce resources and improve management choice. Prioritize allocation of fish and wildlife management resources to ecosystems at highest risk from landscape changes.

#### Policy option or recommendation:

NS-6. Prepare for adaptive management of fish and wildlife.

#### What research is being done/known?

USGS has initiated WildCast research with NPS and FWS for areas north of the Yukon River. The State funded the ANHP to model species at risk 2 years ago, but we have not seen a product. USFWS has extensive experience in assessing risks to rare species.

#### What are the gaps in research?

Research relative to climate change risks is just beginning for most areas and species.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

Alaska state agencies, UA research centers, EPA, other federal agencies

## TWG: Natural Systems

### 5.3.5.3

#### Evaluate and improve methods for caribou population enumeration.

Unique Identifier: 22

Overarching Need

#### Why is this an issue?

Subsistence communities need accurate information to adjust harvest patterns to changing wildlife abundance. Some herds are in decline and others may be. The accuracy and timeliness of caribou monitoring programs has been questioned by stakeholders and cooperators.

#### Describe the scope of the research need:

Evaluate reliability of conducting post-calving photocensus of caribou herds and alternate methods for assessing population abundance. Coordinate more between state and federal partners to incorporate “best methods” for accurate data, when caribou are not grouping for photo census. Evaluate improved census techniques. Use improved DEM data to determine caribou habitat use. Develop protocols for “citizen science” to document arrival, departure of species. Build habitat based models. Couple population data to climate trends, including tundra icing events. An international conference on census, herd composition, and trend methods is warranted to define scope problems and evaluate alternative methods (e.g., mark-recapture for population estimate, sampling effort and statistical power needed for detection of trend).

#### Policy option or recommendation:

NS 6 Fish & Wildlife Management:(6.1) Revise fish & wildlife management to adapt to effects of climate change.

#### What research is being done/known?

Periodic photocensus are conducted and caribou herd movement is tracked by GPS and radiocollars.

#### What are the gaps in research?

Photocensus may miss some groups leading to low estimates. Frequency and accuracy of census techniques may not be sufficient to detect the start of major population drops. Limited data sharing is a long-standing issue among cooperators.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

WACH working group, ADF&G, Canadian provincial agencies, universities, Scandinavians, Russians

## TWG: Natural Systems

### 5.3.5.4

? Assess disjuncts between calendar dates for legal harvest, and actual biological behavior of species. Improve methods for moose population enumeration.

Unique Identifier: 24

Overarching Need

#### Why is this an issue?

Hunters are concerned that legal harvest dates don't always correspond with available harvest opportunities. Managers are concerned that shifting a hunt into the rut period (when bulls are preoccupied with breeding) can increase hunting success, which could be a problem in low-density populations or those with a low bull:cow ratio.

#### Describe the scope of the research need:

☑ Evaluate potential effect of allowing moose hunting during the rut on moose productivity. Evaluate tools or methods for wildlife species assessment. Conduct literature review about effects of temperature on rut timing and the potential effect of allowing moose hunting during the rut on productivity of moose. The most common request to date has been to shift moose hunting seasons later in autumn when weather is cooler (change to warmer weather in early September for parts of the Interior was documented by National Weather Service on request of Alaska Department of Fish and Game in 2008). Research on rutting behavior would require long-term observational studies, which would be challenging in boreal forest. Review data or model the potential effect of shifting moose hunting seasons into early October on the disruption of breeding success, particularly in low-density populations typical of many rural areas of Interior. Evaluate reliability of conducting population estimates or age-sex composition surveys for moose in autumn (before antler drop) compared with surveys in late winter.

#### Policy option or recommendation:

NS-5. Review State regulatory process for wildlife harvest to assure timely adaptation to changing conditions.

☑ NS 6 Fish & Wildlife Management:(6.1) Revise fish & wildlife management to adapt to effects of climate change.

#### What research is being done/known?

#### What are the gaps in research?

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling  Products  Education/Outreach  Data Management  Monitoring

#### Parties involved in implementation:

ADF&G, USGS, UAF



## TWG: Natural Systems

### 5.3.5.5

#### Identify how “sentinel” ecosystems are changing.

Unique Identifier: 182

Overarching Need

#### Why is this an issue?

Continued monitoring in those areas where there are long-term records could provide valuable trend information.

#### Describe the scope of the research need:

Some operational surveys like ADFG small mesh survey in Kachemak Bay, have lost their operational need but provide an excellent indicator of ecosystem change.

#### Policy option or recommendation:

NS-6. Prepare for adaptive management of fish and wildlife.

#### What research is being done/known?

Long-term records of environmental and resource change exist for several areas, but some have been discontinued because their original purpose ended.

#### What are the gaps in research?

ADFG should review their data to see which data can be used to show ecosystem change and continue them for that purpose.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

ADFG

## TWG: Natural Systems

### 5.3.6.1

**Research and monitor forest response after disturbance. Research ecological tipping points.**

Unique Identifier: 8

Overarching Need

#### Why is this an issue?

Trees are moving into higher altitudes and higher latitudes as climate warms. Many common species are experiencing severe and recurring pest outbreaks (e.g., bark beetles, budworms, leaf miners) related to climate change (increased temperatures and transpiration, reduced soil moisture). Fire effects are increasing as flammable shrubs and trees expand into tundra, and as fire frequency increases in boreal forests. However, the full scope and trends has not been determined.

#### Describe the scope of the research need:

Document changes in treeline (fire risk/policy, wildlife habitat) and supply of commercial timber, and merge with fire history and insect outbreak data, especially in areas experiencing the most rapid change. Determine effects of changes in moisture and temperature on growth and survival of forest vegetation species important for commercial and subsistence uses, including response of vegetation after disturbance. Convene working group of scientists and managers to identify key forest vegetation species (fiber and food) and determine status of info needed to predict "tipping points" of rapid change/mortality (e.g., growth rings in spruce and birch approaching zero increment); Research and monitor response of vegetation after disturbance (e.g., fire, insect, disease, logging) For identified info needs, begin experimentation trials or monitoring protocols. Improve understanding of effects of climate change on forest ecosystems; prepare to capitalize on appropriate harvest opportunities.

#### Policy option or recommendation:

- NS-2. Review and modify Alaska's wildland fire policy and programs.
- NS-3. Manage climate change impacts on watersheds and in-stream flows.
- NS-4. Reduce introduction and spread of invasive species in the context of climate change.
- NS-5. Review State regulatory process for wildlife harvest to assure timely adaptation to changing conditions.
- NS-6. Prepare for adaptive management of fish and wildlife.
- NS-7. Develop capacity in new forestry and wood biomass opportunities.

#### What research is being done/known?

LANDFIRE classification of 2001 LANDSAT TM data is being completed now, update with finer resolution and ground-truthing of key communities is desirable (e.g., loss of alpine or low tundra). FS and UAF scientists have documented treeline change and pest outbreaks in many locations across the state.

#### What are the gaps in research?

Document changes in treeline (fire risk/policy, wildlife habitat) and supply of commercial timber (merge with fire history and insect outbreak mapping for age class); Provide focus on areas of most rapid change. Datasets should be merged, analyzed, and mapped in geographic information systems to show recent changes and indicate future trends.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

- Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

USFS, DNR Division of Forestry, USGS, National Park Service (Inventory and Monitoring Program)

## TWG: Natural Systems

### 5.3.6.2

**Assess efficacy, economics, and ecological effects of salvage logging to producing timber and wood biomass fuels from fire- and insect-killed trees.**

Unique Identifier: 49

Overarching Need

**Why is this an issue?**

Climate change related warming and drying is likely to result in more insect and fire-killed timber and biomass.

**Describe the scope of the research need:**

Assess effectiveness, economics, and ecological effects of harvesting small diameter timber (insect- or fire-damaged). Research available types of harvesting equipment for small diameter timber and biomass to facilitate acceptance and use by local commercial contractors. Determine ecological effects of salvage logging (e.g., biomass, nutrient, and habitat removal, effects to soil, permafrost, invasive species). Identify practices that will help to ensure that salvage logging activities and replanting do not introduce invasive species.

**Policy option or recommendation:**

NS-7. Develop capacity in new forestry and wood biomass opportunities.

**What research is being done/known?**

A wide range of equipment and techniques have been developed for use in harvesting larger-diameter timber. Effects on soil fertility and erosion, wildlife and stream habitat from leaving or removing woody material following fires are generally well understood.

**What are the gaps in research?**

Technology transfer. Equipment and techniques need to be tested and adapted for use in Alaska and with smaller material. Effects of salvage harvests in subarctic environments may be less well understood.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

FS, DNR DOF, UAF

## TWG: Natural Systems

### 5.3.6.3

**Test various wood burning appliances and their air quality emissions in an arctic environment.**

Unique Identifier: 185

Overarching Need

**Why is this an issue?**

Increased use of wood and woody biomass as a “carbon neutral” heating fuel has potential to affect local air quality and resident health.

**Describe the scope of the research need:**

Test popular and experimental wood stove devices to rate their efficiency and determine effects on air quality under typical Alaska winter conditions.

**Policy option or recommendation:**

NS-7. Develop capacity in new forestry and wood biomass opportunities.

**What research is being done/known?**

Many wood and pellet stoves have been studied to determine air quality emissions, possibly under optimal fuel and burning conditions. The Cold Climate Housing Research Center (CCHRC) has tested high efficiency wood burning appliances in Fairbanks.

**What are the gaps in research?**

Testing needs to be completed with typical Alaska fuel wood sources and under Alaska air quality conditions.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Health and Culture

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

CCHRC

## TWG: Natural Systems

### 5.3.6.4

#### Research net contributions of Alaska's natural areas to GHG release and sequestration.

Unique Identifier: 55

 Overarching Need

##### Why is this an issue?

Recent climate change is largely driven by greenhouse gas (GHG) levels. The effectiveness of cap and trade measures will also be affected by natural carbon sequestration and emissions. Understanding the relative contribution of sources of GHG compared to other human and natural sources is essential. Accurate modeling is critical for effective mitigation of atmospheric greenhouse gas emissions. Carbon emissions cap and trade systems are now being implemented to reduce global emissions of greenhouse gases. These systems are based on models of gas emissions and gas sinks. Current models cannot accurately determine whether Alaska's wild lands will sequester more carbon in vegetation than they release through wildland fires, oxidation of thawed organic permafrost, methane hydrates, etc.

##### Describe the scope of the research need:

Estimate and research net contribution to greenhouse gases (+ or -) to determine where Alaska lands and waters function as carbon sinks (e.g., forests) or sources (e.g., permafrost thaw, wildfire), as this is likely to become a national priority for mitigating and trading carbon emissions. Research the relative effects of forests, fire, and permafrost thaw on greenhouse gas emissions (e.g. CO<sub>2</sub>, methane) to inform policy decisions about sequestration options and wildland fire response in tundra and boreal forest environments. Develop protocols for certifying carbon storage and sequestration rates for boreal and coastal forests. The concept that wood fuels are carbon neutral should be thoroughly examined. This is a complex topic that involves carbon budgets and cycles in a dynamic environment.

##### Policy option or recommendation:

##### What research is being done/known?

Considerable research and modeling is underway at many levels. NSF funded researchers are also monitoring carbon flux on North Slope soils. Fire simulation modeling by D. Bachelet, et al. (2005) suggests that carbon emissions from forest fires will exceed carbon storage by the end of this century.

##### What are the gaps in research?

Models need to incorporate new and emerging information on emissions from permafrost, fires, methane hydrates, etc. Relative contributions of Alaska's natural areas are largely hypothetical, for lack of hard data on flux rates. Further research on burn intensity mapping and quantification of emissions from recent fires should be completed. Studies should look at both the long- and short-term emissions from fire and changes in the emission dynamics of permafrost response in boreal forest and tundra. Research on the relative contribution of GHG emissions from ecosystems that are independent of fire is also needed to put fire release of GHGs in context (e.g., release of methane CH<sub>4</sub> from melting permafrost; it has >20 times the effect on climate warming than release of CO<sub>2</sub>).

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

##### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

##### Parties involved in implementation:

UAF, NSF, USGS, NASA ACCAP, AFS, JFSP, FS,

## TWG: Natural Systems

### 5.3.7.1

**Agricultural products research. Research new agricultural product opportunities, technologies and best practices in order to prepare to capitalize on opportunities to expand sustainable agriculture in Alaska**

Unique Identifier: 43

Overarching Need

**Why is this an issue?**

Climate change may provide new opportunities in sustainable agriculture, that may be of increased importance to food security as access to other food sources change (e.g., due to loss of fish and wildlife harvest opportunities, or increased costs for shipped foods.)

**Describe the scope of the research need:**

Research and develop new agricultural products, technologies, and best practices to adapt effectively to changing climatic conditions, including agricultural opportunities for small and remote communities. Assess crops having potential for production locally. Assess soils for sustainability for agriculture. Test locally-produced natural products as soil supplements and agricultural fertilizer (e.g., fish waste, compost). Model frost and growing season. Research barriers to community gardening. Assess potential for inadvertent introduction and spread of invasive agricultural species, weeds, and pests.

**Policy option or recommendation:**

NS 1 Agriculture: Support and expand sustainable agriculture in Alaska at the local level

Implementation by: UAF, USDA, DNR DOA

NS-8. Support local sustainable agriculture in Alaska.

**What research is being done/known?**

undetermined

**What are the gaps in research?**

undetermined

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

**Research category/type:**

Modeling    Products    Education/Outreach    Data Management    Monitoring

**Parties involved in implementation:**

DNR, USDA, UAF Cooperative Extension Service

## TWG: Natural Systems

### 5.3.8.1

#### Assess effects of climate on access for hunting, fishing and other subsistence activities.

Unique Identifier: 17

Overarching Need

##### Why is this an issue?

Forecasting is important to enhance safety of travel in road-less areas. Changes in freeze-up timing and conditions continue to affect subsistence harvest opportunities and uses through inaccessibility and/or increased access hazards. Low river water may preclude access. Changes in safe access may require consideration of alternative access means, changes in season timing, or other adaptation. Access by traditional means may also cause resource damage when conditions change (e.g. ORVs or snow machines on wet thawed ground).

##### Describe the scope of the research need:

Assess effects of temperature and rainfall patterns on river level for motor-boat access in autumn and the effect of temperature patterns on ice formation for winter travel on both freshwater ice and sea ice. Forecast sea-ice, river-ice and river flow levels relevant to hunter access. Improve forecasting of river level and sea- or river-ice conditions that affect hunter access. The travel relationships are complex, encompassing both natural sciences (climate, hydrology) and human behavior.

##### Policy option or recommendation:

NS-5. Review State regulatory process for wildlife harvest to assure timely adaptation to changing conditions.  
 NS 6 Fish & Wildlife Management:(6.1) Revise fish & wildlife management to adapt to effects of climate change.

##### What research is being done/known?

##### What are the gaps in research?

For ice travel & access - Request that NOAA in partnership with ADOT&PF develop the capability for improved, higher temporal and spatial resolution sea and river ice forecasts to enhance safety of winter travel in roadless areas (especially relevant to hunter safety.) For river travel & access - Review patterns of rainfall and trends in permafrost melt in river gauge levels in selected areas of the state to understand which indicators may be useful in predicting hunter access. Concurrent interviews with hunters in study sites to correlate firsthand observations in river travel difficulty would be instructive in understanding what proportion of a study areas has access restricted by low water levels for specific types of motor boats.

##### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

##### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

##### Parties involved in implementation:

State, FSP, UAF, ACCAP, land management agencies  
 NOAA, ADOT&PF, USFWS, ADF&G, USGS, University

## TWG: Natural Systems

### 5.3.8.2

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

Unique Identifier: 188

Overarching Need

**Why is this an issue?**

Engineers are sometimes using out of date environmental information in designing new facilities in Alaska.

**Describe the scope of the research need:**

Update and republish the Environmental Atlas with current data, trends and projections of climate change effects.

**Policy option or recommendation:**

**What research is being done/known?**

The Environmental Atlas of Alaska was published in 1978 and remains a standard desk reference for engineers.

**What are the gaps in research?**

Data has been updated in electronic format, but engineers are apparently reluctant to depend on unpublished data, out of liability concerns.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

Transportation and Land Use

Public Infrastructure

**Research category/type:**

Modeling     Products     Education/Outreach     Data Management     Monitoring

**Parties involved in implementation:**

CCREL, ADT



## TWG: Public Infrastructure

### 5.4.1.1

**Collect climate data and develop methodologies and capacity to enhance and increase the resolution of climate forecasting models.**

Unique Identifier: 68

Overarching Need

#### Why is this an issue?

Downscaled climate forecasts are needed so that Federal, state, and community planners & decision makers can establish:

- 1) time horizons within which they will need to address infrastructure fortification or relocation;
- 2) locations and designs of new infrastructure that accommodate these conditions; and
- 3) location-specific conditions that new infrastructure must be designed to accommodate.

#### Describe the scope of the research need:

State scientists, engineers, & decision-makers need to collaboratively update inputs to, revise climatic models as needed, and use models to produce a time sequence of forecasts of expected conditions due to climate change.

#### Policy option or recommendation:

- Develop an adaptive climate change model for public infrastructure that supports development of strategies and approaches to identify short and long-term sustainable solutions to a changing climate.

- Develop and implement sustainable solutions to adapt public infrastructure that is currently at significant risk, and future infrastructure, to the effects of climate change.

#### What research is being done/known?

The University of Alaska has created and invested in the Scenarios Network for Alaska Planning (SNAP) program.

#### What are the gaps in research?

Alaska's climate data collection, management, analysis, and monitoring, infrastructure is sparse and inadequate to effectively meet this research need.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

University of Alaska (SNAP), ADOT&PF, ADF&G, ADNDR, ADCCED, ADEC, DOI, FWS, FS, BLM, NOAA, NWS, AOOS,

## TWG: Public Infrastructure

### 5.4.1.2

**The State needs to develop and deploy effective mechanism(s) to increase the availability and maximize the exchange of authoritative, defensible, and timely information to support analysis and decision-making on issues of climate change adaptation & mitigation, sustainability, and resiliency.**

Unique Identifier: 146

Overarching Need

#### Why is this an issue?

Climate analysis information delivery and availability is decentralized and uncoordinated, creating inefficiency, duplication of effort, wasted money, and difficulty in locating information of consistent and acceptable quality for a variety of purposes.

#### Describe the scope of the research need:

Mechanisms to increase information availability and collaboration must maximize the diversity of information suppliers and users - including public and private agencies, rural and urban citizens, scientists, engineers, planners, and decision-makers. Investment in an information clearinghouse requires increased commitment to continuous maintenance of a dynamic, integrated, information exchange mechanism that seamlessly supports information suppliers and users. Key services include:

- Knowledge management (archiving, updating, synthesizing)
- Interactivity (user-customized information delivery)
- Rapid data updates

#### Policy option or recommendation:

The state should collaboratively develop, establish, and effectively maintain an integrated, interactive information clearinghouse for policy, science, engineering standards, public discourse, and data pertaining to sustainable development and resiliency in Alaska.

#### What research is being done/known?

The University of Alaska has created the Alaska Center for Climate Assessment & Policy (ACAP), developed a "Resilience and Adaptation interdisciplinary Ph.D. program, and invested in the Scenarios Network for Alaska Planning (SNAP) program. The Alaska Department of Transportation & Public Facilities and the U.S. Army Corps of Engineers Cold Regions Research & Engineering Laboratory (CRREL) has invested in the Alaska Engineering Design Information System (AEDIS). The University of Alaska has Developed the Geographic Information Network of Alaska (GINA). Web 2.0 social networking tools, "Wikis", and GIS data conversion tools offer promising models.

#### What are the gaps in research?

Legal defensibility, data analysis conversion algorithms, and development of tools for management of distributed database elements are areas that need additional investment in research and development in Alaska.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

University of Alaska, ADOT&PF, ADEC, ADNR, ADCCED, DOI, ADFG, Alaska Department of Law, Alaska Legislature, DOI, DOD, CRREL, and other government, private, and industry organizations.

## TWG: Public Infrastructure

### 5.4.1.3

**The state needs to develop a mechanism to systematically identify, collect, and analyze the data that it needs to economically plan, develop, and manage its public infrastructure in a sustainable manner.**

Unique Identifier: 145

Overarching Need

#### Why is this an issue?

The state's current project-based focus on infrastructure development discourages investment in the systematic collection and evaluation of long-term post-construction performance data after construction. Infrastructure performance monitoring and modeling is necessary to effectively evaluate if and how infrastructure might be developed more sustainably in Alaska.

#### Describe the scope of the research need:

Research is needed to:

- Identify barriers to scenario-based planning,
- Optimize investment in visualization tools for public involvement and planning,
- Determine which data and parameters are critical for increasing sustainability of infrastructure,
- Identify the best and most economical sources of data?
- Optimize investment in climate forecasting and modeling.
- Develop probabilistic models, planning, and design tools useful for planners, engineers, and decision-makers.
- Economically manage risk.

#### Policy option or recommendation:

The state should develop a strategic plan for data collection specifically to support planning, design, construction of sustainable public infrastructure. The strategic plan for data collection should directly support the State's comprehensive, integrated, and interagency asset management policy to guide public infrastructure planning and investment in Alaska.

#### What research is being done/known?

Implementable research on sustainable asset management is available from the Transportation Research Board of the National Academies. Other states have adopted best management practices that Alaska should emulate.

#### What are the gaps in research?

Those involved in the planning, financing, design, construction, and maintenance of public infrastructure in Alaska are not benefitting from knowledge that could be gained by systematic investment in collecting infrastructure performance data.

**If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?**

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

ADOT&PF, CRREL, University of Alaska, Governor's Office of Management & Budget, Alaska Legislature

## TWG: Public Infrastructure

### 5.4.2.1

Analyze, develop, and update existing engineering and building codes and construction techniques for new infrastructure and structures in vulnerable areas.

Unique Identifier: 120

Overarching Need

#### Why is this an issue?

Current designs likely do not incorporate the real risks and variability associated with climate change in Alaska. Consequently infrastructure may fail prematurely or require unnecessary expense to build and maintain, resulting in uneconomical and unacceptable risks to Alaskan communities.

#### Describe the scope of the research need:

It is likely that building, electrical, mechanical, materials, and sanitation design codes will need further research and testing to include new data collection, analysis, and modeling. All of this will require long-term investment and potentially the creation of new programs.

#### Policy option or recommendation:

The State of Alaska should adopt a statewide public infrastructure risk management policy.

#### What research is being done/known?

The University of Alaska has created the Alaska Center for Climate Assessment & Policy (ACAP) and invested in the Scenarios Network for Alaska Planning (SNAP) program. The Alaska Department of Transportation & Public Facilities and the U.S. Army Corps of Engineers Cold Regions Research & Engineering Laboratory (CRREL) has invested in the Alaska Engineering Design Information System (AEDIS). The University of Alaska has Developed the Geographic Information Network of Alaska (GINA).

#### What are the gaps in research?

Many existing infrastructure planning and engineering criteria, codes, and standards were developed with data that does not include the effects of climate change, especially in Alaska. Additionally, many of these techniques are based on deterministic methods that have limited ability to capture the effects of recent changes and variability of climate change.

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Energy Supply and Demand  
Transportation & Land Use

#### Research category/type:

Modeling     Products     Education/Outreach     Data Management     Monitoring

#### Parties involved in implementation:

Department of Transportation & Public Facilities, University of Alaska, Department of Commerce, Community & Economic Development, Local and Municipal Governments, Industry professional organizations. Alaska Legislature

## TWG: Public Infrastructure

### 5.4.2.2

**Establish an integrated baseline inventory on the location and condition of public infrastructure. Collect, assess and monitor data needed to develop sustainable solutions to adapt public infrastructure to the effects of a changing climate.**

Unique Identifier: 67

Overarching Need

#### Why is this an issue?

A complete inventory of public infrastructure (that is either now, or likely to be, at risk from the effects & hazards due to climate change) is needed in order to systematically identify public infrastructure vulnerability. Data that does exist is owned by several agencies and not effectively integrated and shared amongst. Inefficient duplication of effort is likely given the functionally separate organization and operations of State agencies.

#### Describe the scope of the research need:

The State needs to create an integrated inventory and document the condition of public infrastructure at risk due to the current and projected effects of climate change.

#### Policy option or recommendation:

The State should adopt a comprehensive, integrated, and interagency asset management policy to guide public infrastructure planning and investment in Alaska.

#### What research is being done/known?

1. ISER developed a preliminary and limited database of existing public infrastructure and projected the added cost (above normal wear and tear) from the effects of climate change on infrastructure at risk. See Larson, P.H., et al. (2008).

2. ADCCED's Division of Community and Regional Affairs (DCRA) maintains an online community databases that provide general information on community location, population, taxes, climate, history, culture, demographics, utilities, schools, health care, economy, transportation, contacts and capital projects and grants. Most of the public infrastructure is listed under the "Facilities, Utilities, and Services" data type. However, this information is limited and dated.

#### What are the gaps in research?

Existing State community and infrastructure databases are not comprehensive or contain insufficient information for asset management purposes. For example, the DCRA database does not provide information on the physical and environmental conditions (permafrost, river and coastal shorelines, etc.) that exist where the existing public infrastructure is located. Instead of maintaining a comprehensive database, ADOT&PF's archives data on individual transportation projects as they are built and does not regularly conduct condition monitoring. DCRA's Alaska Capital Projects Database was originally the "Rural Alaska Project Information Delivery System" (RAPIDS), which tracks capital funding for projects in rural Alaska. RAPIDS provided a place for agencies to list ongoing projects and collaborate with other agencies on project timing. In January of 2006, RAPIDS was changed to Alaska Capital Projects Database because the system is no longer exclusively for rural Alaska. The link to these databases: [http://www.commerce.state.ak.us/dca/commdb/CF\\_COMDB.htm](http://www.commerce.state.ak.us/dca/commdb/CF_COMDB.htm)

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Energy Supply and Demand  
Transportation & Land Use

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

ADCCED, ADEC, ADOT&PF, NOAA, University of Alaska, Alaska Legislature,

## TWG: Public Infrastructure

### 5.4.2.3

**Identify, analyze, and use national and international research results and products as a basis for developing solutions and expanding best management practices in AK.**

Unique Identifier: 141

Overarching Need

#### Why is this an issue?

Employees of Alaska State agencies are not consistently clear about the role their agencies play in developing and supporting sustainable and resilient infrastructure. Performance measures of state agencies do not consistently recognize a systems approach and the value of sustainability and resiliency for state investments. State leaders have a tendency to manage public infrastructure funding decisions as expenses rather than investments.

#### Describe the scope of the research need:

State agency leaders and managers must make sustainability and resiliency an effective priority and develop guiding coalitions to create a supportive culture in their organizations.

#### Policy option or recommendation:

- Require that state agencies involved in infrastructure planning, development, delivery, operation, and maintenance include explicit support for the development sustainable and resilient infrastructure in their vision & mission statements and strategic plans.
- Identify and remove institutional barriers to innovation and collaboration.

#### What research is being done/known?

The Transportation Research Board has created many research products and guides to assist Transportation Departments.

#### What are the gaps in research?

#### If this is a Cross-Cutting issue, what other topics (TWGs) does it apply to?

Energy Supply and Demand  
Transportation & Land Use

#### Research category/type:

Modeling    Products    Education/Outreach    Data Management    Monitoring

#### Parties involved in implementation:

ADOT&PF, ADEC, ADFG, ADCCED, Alaska Department of Law, Governor, Alaska Legislature

# Appendix B

Letter to Governor's Sub-Cabinet on Climate Change

December 3, 2008

To: Governor's Sub-Cabinet on Climate Change  
From: The Interagency Hydrology Committee for Alaska  
Subject: Hydrology Needs for Alaska

The Interagency Hydrology Committee for Alaska (IHCA) is an organization of technical specialists working for Federal, State, borough, and local governments and Federally recognized tribes, who coordinate the collection and interpretation of data related to water resources and climate throughout the State of Alaska.

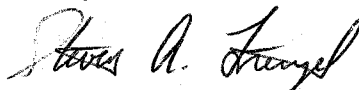
As you are well aware, climate change, particularly current warming trends in the high latitudes, is leading to changes in Alaska's freshwater, estuarine, and marine environments. One of the best measures of the rate and magnitude of change, and perhaps the most impacted natural resource in terms of both timing and quantity changes, is in fact water volume and associated characteristics. For example, rivers and lakes freeze over later in the year and become ice-free earlier in the year, permafrost is thawing, and precipitation patterns are changing. Agencies and communities in Alaska have become increasingly aware of the emerging and potential effects of climate change. However, the authorities charged with protecting the public safety and managing natural resources in the best public interest require appropriate information and tools to take specific actions in response to and preparation for changing environments.

IHCA has developed the following list of topics that are especially important to detecting, quantifying, and adapting to climate-driven change and recommend that research and monitoring in support of state and local needs be encouraged and supported with the highest priority:

- Extent of permafrost and the effects of changing permafrost on subsurface hydrology, aquifer yield, and lake draining or formation;
- Baseline flow and water volume conditions of rivers and lakes versus changing spatial and temporal hydrologic patterns, such as changes in seasonality, flood magnitude, and drought severity;
- The spatial and seasonal distribution, timing, intensity, and state of precipitation;
- Freeze-up, break-up, ice thickness, and ice jams on lakes and rivers;
- Extent of glacier mass changes, the contribution of glacier melt to streamflow, and frequency of outburst floods;
- Geologic and geotechnical trends related to active layer detachments, mass wasting, and sloughing;
- Avalanche timing, prevalence, and trends;
- Socio-economic cost to address changing conditions of water availability and quality;
- Erosion and sediment transport effects resulting from changes in runoff patterns;
- Short and long term planning for water supply, demand, and support infrastructure to mitigate emerging and anticipated environmental change.

IHCA will be happy to provide additional details, including specific agency projects and outstanding needs that will benefit from the hydroclimatic research listed here. We are also happy to provide technical support to your group upon request.

Sincerely,



Steven A. Frenzel  
Chair, Interagency Hydrology Committee for Alaska



