Arctic Landscape Conservation Cooperative

Future Needs Assessment

An Assessment and Ranking of Current and Future
Science and Information Needs
Identified by Land and Resource Managers
Working in Alaska's Arctic Region

February 2013

Table of Contents

Introduction

The Arctic Landscape Conservation Cooperative (Arctic LCC) Steering Committee conducted an assessment of science and information needs identified by land and resource managers working in Alaska's Arctic, with a focus on needs related to expected changes in climate. The primary objective of the Future Needs Assessment is to determine how the Arctic LCC can best support and strengthen the connection between science and management in the area of climate change. The assessment will inform decisions regarding allocation of LCC funding and effort from 2013 forward, and also helps illustrate the relevance of the LCC's work to date to decisions regarding land and resource management in the Arctic.

The Future Needs Assessment was developed through interviews with 27 representatives of federal, state and local government agencies with management and scientific research responsibilities in the Arctic. Interviews focused on identifying scientific and other information that would be substantially useful to managers in their current work and 30 years in the future, as they make land and resource management decisions in a time of expected climate change. Other topics addressed in the interviews included the importance of climate change relative to other sources of change in affecting future resource management decisions, adaptation actions that agencies might expect to take in the future as ecological systems change, and how the Arctic LCC can most effectively provide information to management agencies.

As a primary product of the Future Needs Assessment, the LCC Steering Committee developed a prioritized list of 46 science and information needs, in four categories: physical parameters and processes; biological parameters, processes and responses; applied information and decision support tools; and human environment and cultural resources. The needs were ranked using a common set of criteria developed by the committee and the prioritized list was approved by the Steering Committee on January 9, 2013.

Relationship to Other Arctic LCC Strategic Documents

This Future Needs Assessment is one of several documents that provide strategic direction for the Arctic LCC. Together, these documents guide the Steering Committee and staff to ensure that the LCC's work is addressing the highest priority landscape scale conservation issues in the Arctic. Additional documents that provide strategic guidance to the Arctic LCC include:[1]

- *Arctic LCC Mission* – The mission of the Arctic LCC is to identify and provide information needed to conserve natural and cultural resources in the face of landscape scale stressors, focusing on climate change, through a multidisciplinary program that supports coordinated actions among

[1] Strategic documents and additional information about the Arctic LCC can be found at www.arcticlcc.org

management agencies, conservation organizations, communities, and other stakeholders.

- *Arctic LCC Charter* (October 2010) – The Arctic LCC's Charter defines the purpose, mission and geographic scope of the LCC. It clarifies that the LCC's initial efforts will focus on the geographic area influencing management decisions in the Alaska portion of the Arctic LCC.
- *Conservation Goals* (August 2010) – The Arctic LCC's priority conservation goals have been identified by the Steering Committee as:
    1. Better understand and predict effects of climate change and other stressors on landscape level physical and ecosystem processes.
    2. Better understand the impacts of environmental change on subsistence and cultural resources.
    3. Provide support for resource conservation planning.
    4. Contribute to improved data management and integration.
- *Strategic Science Plan* (December 2012) – The Arctic LCC's strategic science plan outlines monitoring, research and modeling activities for the next ten years, with review and potential revisions at three-year intervals. The plan states that the LCC will focus primarily, but not exclusively, on climate change, with an emphasis at this time on terrestrial, freshwater, and nearshore marine systems. Within the marine system, the LCC will place priority on topics that address linkages between that system and terrestrial or freshwater system. The Science Plan also describes the LCC's three Technical Working Groups (Geospatial, Species and Habitat, and Physical Processes), and the LCC's interest in and intent to incorporate local concerns into its science planning process.

Methodology

The Future Needs Assessment was developed through four steps:[2]

1. Interview land and resource managers to compile a list of science and information needs they recommend the Arctic LCC work on or support, particularly in the area of climate change.
2. Establish criteria for the Steering Committee to use in ranking the science and information needs.
3. Steering Committee ranks the science and information needs.
4. Steering Committee reviews and validates the ranked results and discusses how this assessment will be used in the future.

[2] The Arctic LCC contracted with the Institute for Environmental Conflict Resolution (www.ecr.gov) and Jan Caulfield Consulting (www.jancaulfield.com) to work with the Steering Committee and staff to prepare the Future Needs Assessment.

1. Interview land and resource managers – In October 2012, interviews were conducted with 27 representatives of federal, state and local land and resource management agencies working in Alaska's Arctic. Agency representatives to be interviewed were identified by the Steering Committee. The number of people interviewed at each agency is indicated below.

<u>Federal agencies</u>
Bureau of Land Management (3)
Bureau of Ocean and Energy Management (3)
National Oceanic and Atmospheric Administration (3)
US Arctic Research Commission (1)
US Army Corps of Engineers (2)
US Fish and Wildlife Service (3)
US Geological Survey (3)

<u>State of Alaska</u>
Alaska Department of Fish and Game (1)

<u>Local governments</u>
North Slope Borough (1)
Northwest Arctic Borough (4)

The interviews used standardized questions, but were not designed to yield quantitative results. Interview questions and background information about potential changes in Alaska's Arctic environment were provided to interviewees in advance, to allow people to prepare and to stimulate thinking about the types of information each agency may need to support its future management in a changing environment (Appendix 1).

Interview results are summarized in Appendix 2. For questions 5-7, the science and information needs related to climate change identified by interviewees were grouped into 46 different types of needs, in four categories: physical parameters and processes; biological parameters, processes and responses; applied information and decision support tools; and human environment and cultural resources. These 46 needs are listed on pages 28-44 in Appendix 2.

Interview results were presented to the Steering Committee via webinar on November 20, 2012. The committee reviewed these results prior to ranking the science and information needs (discussed below). Notes from the 27 interviews have been provided to the Arctic LCC staff as additional background material relevant to the assessment.

2. Establish criteria for ranking science and information needs – The Steering Committee met twice via teleconference to develop criteria to use in ranking the science and information needs that resulted from the interviews. On November 20, 2012, the Steering Committee discussed draft criteria, which were then circulated for committee member comments. On December 7, 2012, the Steering Committee approved a final set of criteria, provided in Appendix 3.

3. Steering Committee rank science and information needs – Steering Committee members individually ranked the 46 science and information needs according to the established criteria. Seven members of the Steering Committee completed the ranking process prior to the committee meeting on January 9, 2013. Three additional Steering Committee members entered rankings following the meeting. The results below (Table 1) are a compilation of the rankings completed by these ten committee members.

The ranking process was facilitated by use of MeetingSphere,[3] a tool that made it possible for Steering Committee members to complete the rankings online. The Institute for Environmental Conflict Resolution (ECR) provided technical support for this step in the process.

The results of the ranking process were reviewed by the Steering Committee on January 9, 2013, and are presented in the following section.

4. Steering Committee validates ranked results – The Arctic LCC Steering Committee met in person on January 9, 2013 in Anchorage.[4] At this meeting, the committee directed that the compiled rankings completed by the ten committee-members who participated in the ranking process be used as the final list of science and information needs for the Future Needs Assessment report. They also directed that all 46 needs be retained on the list.

On January 9, the Steering Committee considered whether there would be any added value in modifying the list of science and information needs that resulted from the ranking process. Potential modifications might have included combining or renaming some needs, changing the priorities based on group discussion and deliberation, or eliminating needs that are of very low priority. However, after discussion, the Steering Committee reached consensus that it did not want to make changes to the list. They found the list to be a useful tool for the LCC without further modification. The committee accepted it as a final product that will guide (but not constrain) the LCC in its future decisions about science priorities. Notes from the January 9, 2013, Steering Committee meeting are provided in Appendix 4.

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[3] www.meetingsphere.com

[4] Steering Committee members or alternates in attendance included: Catherine Coon, Bureau of Ocean Energy Management (BOEM(; Amy Holman, National Oceanic and Atmospheric Administration; Frank Hays, National Park Service (NPS); Michael Salyer, US Army Corps of Engineers; Jim Lawler, NPS; John Pearce; US Geological Survey (USGS); Anne Marie LaRosa, US Fish and Wildlife Service; Cheryl Rosa, Arctic Research Commission; Doug Vincent-Lang, Alaska Department of Fish and Game; Dee Williams, BOEM; Dave Yokel, Bureau of Land Management. Additional attendees included Steve Gray, USGS; Philip Martin, Arctic LCC; Jan Caulfield; and Raquel Goodrich, ECR.

Assessment Results – Prioritized Science and Information Needs

Table 1 presents the prioritized list of 46 science and information needs identified by land and resource managers working in Alaska's Arctic as being important to support management decisions in a changing Arctic environment. The science and information needs are listed in ranked priority (based on application of criteria by ten Steering Committee members).

For each need, the table also indicates the number of interviewees who identified this need, the number who identified it as one of their top two or three priority needs, and the number who wanted to have access to status and trends data for this information need. (These interview results were drawn from Appendix 2.)

The Arctic LCC Steering Committee has approved Table 1 as the primary final product of the Future Needs Assessment. As noted above, it will be used as one source of strategic direction to consider in the LCC's future decisions about science priorities, funding, and support for and participation in other cooperative work, along with other relevant direction and existing agreements (see *Relationship to Other Arctic LCC Strategic Documents*, above).

In addition to the prioritized list of science and information needs listed in Table 1, Appendix 2 provides the responses of the interviewees to a wider range of interview questions. The Steering Committee did not discuss these responses at its January 9, 2013, meeting. However, the interview responses are appended for future consideration by the committee and LCC staff.

Conclusion

On January 9, 2013, the Arctic LCC Steering Committee approved a prioritized list of science and information needs (Table 1) as a primary product of the Future Needs Assessment. The Steering Committee found that the results of the Future Needs Assessment validate the direction that the Arctic LCC has taken in its work to date, including projects accomplished by staff or funded by the LCC in 2010-2012, interdisciplinary project plans solicited by the LCC and under consideration for funding in 2013, and the scientific focus outlined in the 2012 Strategic Science Plan. The results indicate that the LCC's program of work is relevant to the needs of land and resource managers working in Alaska's Arctic region. The list of science and information needs and other input provided through interviews with federal, state and local government land and resource managers will guide the Arctic LCC in its future decisions regarding its program of work.

Table 1 - Future Needs Assessment - Summarized Results Table Ranking of Responses from 27 Interviews by 10 Arctic LCC Steering Committee Members													
		Criteria Used to Rank Science / Information Needs									Information from Interview Responses		
		1. Mission/ Goals	2. Applicability	3. Scope	4. Eco/Cultural	5. Timeliness	6. Contribution	7. Feasibility	Total points	Average points	No. people identified need	No. people identifed need as top priority	No. who wanted status and trends information
ID #	Science / Information Need	See footnote (1)	See footnote (2)						See footnote (3)				
21	Fish and wildlife - effects of environmental change on fish and wildlife habitat use patterns	1	4.60	4.40	4.70	4.20	4.50	4.10	26.50	4.42	10	1	3
1	Hydrology / Hydrography - baseline mapping of surface & groundwater dynamics & distribution; modeling, forecasting	1	4.40	4.30	4.30	4.00	4.90	3.90	25.80	4.30	21	3	15
2	Coastal erosion - mapping, modeling, forecasting	1	4.10	3.80	3.90	4.00	4.40	4.40	24.60	4.10	18	10	8
41	Community subsistence harvest - systems, change	1	4.10	4.10	4.60	4.00	4.10	3.40	24.30	4.05	7	2	4
4	Permafrost (and soils) - mapping, modeling, forecasting	1	4.10	4.00	4.00	3.70	4.30	4.10	24.20	4.03	13	6	8
18	Season length - freezeup, breakup, greenup date	1	3.80	3.80	4.20	3.90	4.10	4.30	24.10	4.02	1	1	1
5	Sea level rise / coastal flooding	1	3.80	4.00	4.00	3.50	4.00	4.10	23.40	3.90	5	3	2
22	Plant communities - predicted shifts in distribution and composition	1	4.00	4.00	4.00	3.70	3.90	3.70	23.30	3.88	7	0	5
33	Outreach - policymakers, public	1	3.78	4.00	3.78	3.78	3.78	4.11	23.23	3.87	3	1	0
23	Explore and describe linkages between physical drivers and biological responses	1	3.70	3.80	3.90	3.90	4.00	3.40	22.70	3.78	4	3	0
42	Human dimensions of change - effects on residents of the Arctic (demographics, community locations, areas of human use & activity)	1	3.90	3.80	4.10	3.90	3.90	3.10	22.70	3.78	6	3	0
43	Contaminants - baseline levels, risk	0.9	3.89	3.67	3.70	3.67	3.67	4.00	22.60	3.77	3	0	2
7	Weather - trends, storms, waves, extremes	1	3.50	3.90	4.00	3.50	3.70	3.90	22.50	3.75	5	1	1
8	Temperature - baselines, change, modeling, forecasting	1	3.60	3.30	3.60	3.60	3.80	3.90	21.80	3.63	4	2	3

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ID #	Science / Information Need	See footnote (1)	See footnote (2)						See footnote (3)				
38	Trend analysis - to support decisions/stipulations/mitigation & monitoring that are adaptive to expected changes	0.9	3.78	3.89	3.11	3.33	3.89	3.33	21.33	3.56	1	1	0
31	Modeling & forecasting; evaluation of the predictions over time	1	3.40	3.80	3.40	3.40	4.00	3.30	21.30	3.55	6	2	0
20	Fish and Wildlife - status and trends for specific species	0.9	3.44	3.56	3.78	3.44	3.33	3.22	20.77	3.46	13	5	10
26	Coastal / nearshore ecosystem ecology	1	3.50	3.20	3.80	3.30	3.50	3.40	20.70	3.45	3	0	0
32	Downscaled modeling - Models at sub-region or local area scale	0.8	3.56	3.11	3.22	3.22	3.78	3.78	20.67	3.45	3	2	0
44	Cultural Resources - Identify & expand inventory of high risk cultural resource areas	0.8	3.11	3.11	3.89	3.44	3.33	3.44	20.32	3.39	2	0	1
3	Sea ice - mapping, trend analysis, forecasting (and conversely, open water)	0.9	2.80	3.00	3.50	3.20	2.80	4.00	19.30	3.22	15	5	8
24	Invasive species	0.8	3.13	2.88	3.25	3.13	2.88	4.00	19.27	3.21	4	0	3
15	Precipitation	1	3.10	3.40	3.30	2.80	3.10	3.40	19.10	3.18	2	1	1
36	Planning tools (for communities) that address climate change issues and effects	0.9	2.89	3.11	3.33	3.11	3.11	3.22	18.77	3.13	1	1	0
10	Snow pack - depth, seasonality	1	2.90	3.20	3.30	2.70	3.33	3.30	18.73	3.12	3	1	3
35	Data portal - integrated, cross-agency data storage and access	0.9	3.00	3.50	2.50	3.50	3.30	2.90	18.70	3.12	2	0	0
25	Fish and wildlife - changes in behavior, phenology	0.9	3.00	3.11	3.33	3.00	3.11	3.11	18.66	3.11	3	1	2
27	Fish assemblages	1	3.20	2.80	3.20	3.00	3.00	3.10	18.30	3.05	2	0	0
17	Water quality	0.9	2.80	3.20	3.30	3.00	2.70	3.20	18.20	3.03	2	0	2

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		1. Mission/ Goals	**2. Applicability**	**3. Scope**	**4. Eco/Cultural**	**5. Timeliness**	**6. Contribution**	**7. Feasibility**	**Total points**	**Average points**	**No. people identified need**	**No. people identifed need as top priority**	**No. who wanted status and trends information**
ID #	**Science / Information Need**	**See footnote (1)**	**See footnote (2)**						**See footnote (3)**				
34	Adaptation actions - Scenario planning to inform future adaptation actions (related to biological resources)	0.9	3.11	2.78	3.22	2.78	3.00	2.67	17.56	2.93	2	0	0
39	Protocols for factoring climate change into NEPA processes - providing training	0.7	2.88	2.63	2.75	3.00	2.75	3.50	17.51	2.92	1	0	0
16	Nutrient cycling	1	2.90	2.70	3.20	2.70	2.90	2.80	17.20	2.87	2	1	1
19	Inland coastal plain physiography - modeling surface of inland coastal plain; effects on hydrology & surface water	1	3.20	2.80	2.90	2.60	2.90	2.70	17.10	2.85	1	0	0
45	Point source human effects on Arctic environment (e.g., communities, industrial sites, transportation corridors)	0.7	2.71	2.71	3.14	3.00	2.86	2.57	16.99	2.83	1	0	1
12	Glacier changes	0.9	2.56	2.44	2.67	2.67	3.00	3.33	16.67	2.78	3	1	1
11	Fire regime - modeling, forecasting	0.9	2.78	2.67	2.67	2.33	2.67	3.22	16.34	2.72	3	1	1
14	Physical oceanography - currents, temperature, other parameters	0.6	1.88	2.75	3.13	3.13	2.00	3.13	16.02	2.67	3	0	1
13	Riverine erosion	0.9	2.80	2.70	2.80	2.30	2.80	2.60	16.00	2.67	3	1	1
29	Alpine ecology	0.9	2.44	2.44	2.78	2.67	2.67	3.00	16.00	2.67	1	0	0
28	Small mammal assemblages	1	2.70	2.30	2.30	2.80	2.50	3.00	15.60	2.60	1	0	1
40	Risk management - guidance for managers with determining risk and consequences	0.7	2.50	2.75	2.25	2.50	2.88	2.50	15.38	2.56	1	0	0
37	Standard methods for international cross-boundary inventory and monitoring	0.8	2.22	2.44	2.33	1.78	2.89	2.67	14.33	2.39	1	1	0
30	Arctic engineering - research to inform how to design and construct infrastructure to withstand changing climate (e.g. permafrost changes) & to minimize habitat impacts	0.6	1.88	2.00	2.25	2.25	2.63	3.00	14.01	2.34	8	3	0
6	Ocean acidification	0.8	1.89	1.89	2.56	2.00	1.89	2.33	12.56	2.09	5	2	2

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Ranking of Responses from 27 Interviews
by 10 Arctic LCC Steering Committee Members

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		1. Mission/ Goals	2. Applicability	3. Scope	4. Eco/Cultural	5. Timeliness	6. Contribution	7. Feasibility	Total points	Average points	No. people identified need	No. people identifed need as top priority	No. who wanted status and trends information
ID #	Science / Information Need	See footnote (1)	See footnote (2)						See footnote (3)				
46	Infrastructure conditions and replacement needs	0.5	1.56	1.86	1.71	2.57	2.29	2.43	12.42	2.07	1	0	0
9	Air quality - Monitoring and modeling of air quality	0.8	1.75	1.88	2.63	2.13	1.88	2.13	12.40	2.07	4	2	2

Footnotes

(1) Criteria 1 (Mission/Goals) was scored in a binary fashion. 1 = information needs meets the LCC's mission/goals; 0 = it does not. Column provides mean score (n=10) for ranking of criteria 1, specific to each science/information need.

(2) Columns provide mean score (n=10) for the ranking of criteria 2-7, specific to each science/information need.

(3) Total and average of points given for criteria 2-7 (n=10).

Arctic Landscape Conservation Cooperative
Future Needs Assessment – Interview Packet

The Arctic Landscape Conservation Cooperative (Arctic LCC) is undertaking a "Future Needs Assessment" focused on how the LCC can best support and strengthen the connection between science and resource management in Alaska's Arctic. Through interviews with state, federal and local government representatives, the Arctic LCC Steering Committee is seeking to determine:

- What information about climate change is most important to management agencies to support current and future resource management decisions in the Arctic?
- What is the relative importance of climate induced changes versus other sources of change in affecting future resource management decisions in the Arctic?
- How can the Arctic LCC most effectively provide the information that management agencies need (specifically, most useful format).

The Arctic LCC Steering Committee will use input from the interviews to develop a strategic framework that identifies and prioritizes the information needed to inform future resource management decisions in the Arctic, through the lens of expected future climate scenarios. The strategic framework will guide the Arctic LCC in collecting, supporting and dispersing information that will be most useful to managers. In addition, the process will address the relative importance of non-climate related changes to future management, so the LCC can better evaluate its focus on climate change as it carries out its work.

The Steering Committee appreciates your participation in the interview process and asks that you use the attached material to prepare for the interview. This document includes:

- Interview questions – Please review these questions and give thought to your responses prior to the interview, so that we can be efficient with your time and get as complete information as possible.
- Brief background information regarding key areas of potential landscape-scale change in the Arctic to stimulate your thinking about the information that will be needed to support resource management in the future.

Arctic LCC Mission and Goals

Established in 2010, the Arctic LCC is a partnership among federal, state, and local governments, tribes, nongovernment organizations, academic institutions and other entities operating within northern Alaska and northern Canada.

The mission of the Arctic LCC is to *"identify and provide information needed to conserve natural and cultural resources in the face of landscape scale stressors, focusing on climate change, through a multidisciplinary program that supports coordinated actions among management agencies, conservation organizations, communities, and other stakeholders."*

The LCC has adopted four priority conservation goals for its work:

1. Better understand and predict effects of climate change and other stressors on landscape level physical and ecosystem processes.
2. Better understand the impacts of environmental change on subsistence and cultural resources.
3. Provide support for resource conservation planning.
4. Contribute to improved data management and integration.

More information about the Arctic LCC is available at http://arcticlcc.org

Interview Questions

1. What general types of resource management decisions does your agency/organization make in Alaska's Arctic on a regular basis now?

2. Thinking ahead up to 30 years in the future, to what extent and in what ways do you expect projected climate-driven changes in the Arctic to affect the types of decisions your agency will be making?

3. How important do you expect climate-driven changes to be in influencing your agency's future management in the Arctic, compared to other non-climate factors (such as changes in human population, subsistence needs, resource development, infrastructure, maritime traffic, or other factors)?

    - If you think that non-climate factors will significantly affect your agency's future management in the Arctic, which <u>three non-climate factors</u> do you expect will be most significant?

4. Do you take climate change information into account now, in your agency's <u>current management</u> decisions?

    - If Yes – What types of information related to climate effects on the landscape do you use?

    - If No – Why not? (For example, is it because you believe climate effects are not relevant to your decisions at this time, because you don't find sufficient climate change information to be available, or other?)

5. If you have not found sufficient climate change information to be available, what additional information would you like to have to address <u>current management</u> objectives and support management decisions?

    - For each information need that you identify, indicate why it is relevant to your management objective or decision.

6. Thinking ahead up to 30 years in the future, what are the most significant information needs related to climate-driven changes that you would like to have addressed to inform <u>future management</u> decisions? Think in terms of information that would help with management of human activities (e.g., cultural resource management, structural engineering in a changing Arctic environment), as well as natural ecosystem management.

    - For each information need that you identify, indicate why it would be relevant to a future management objective or decision.

7. Is it important to know the status and trend of physical and biological elements of the Arctic ecosystem? Why or why not?
    - If so, can you identify particular variables or parameters of interest to your agency?
    - Is either historical trend or forecasting more useful, or both?
8. As ecological systems change in the future, is your agency likely to: (1) intervene to try to preserve the status quo, (2) take no specific action with regard to the change that occurs, or (3) facilitate change through adaptation actions?[1] (Examples of adaptation might include developing and using alternative approaches to resource development, armoring stretches of shoreline, or designation of protected natural and cultural areas.) Or, do you think that it is premature to think about adaptation actions in the Arctic?
9. If your agency is likely to take adaptation actions on a broad or site-specific scale, what might those actions be?
    - Thinking in terms of <u>future adaptation actions</u> that your agency might take, are there any other information needs related to climate change that your agency would have that you haven't already mentioned above?
    - For each information need that you identify, indicate why it would be relevant to support future adaptation actions.
10. In what format would climate change information most usefully be provided to you? (Examples of formats that the LCC currently uses include provision of data sets, geospatial products, research reports, conferences or web presentations. Are these the most useful formats, or do you have other suggestions?)
11. Thinking back on our discussion, what are your agency's top two or three information needs related to climate change that you would like the Arctic LCC to address? Why are these your highest priority for inclusion in the LCC's strategic framework?

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[1] "Adaptation" is defined by the Intergovernmental Panel on Climate Change (IPCC) as the "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploits beneficial opportunities." (IPCC 2007, Glossary)

Key Elements of Future Landscape Change in Alaska's Arctic

The following information about potential changes in Alaska's Arctic environment is provided to stimulate thinking about the types of information your agency may need to support its future management decisions in a changing environment.

Projected Changes in Ecosystem Drivers

Figures 1-4 depict modeled projections of the magnitude of change in air temperature, precipitation, length of growing season, and seasonal depth of thaw or freeze. The projections depicted in Figures 1-3 assume carbon emissions follow the Intergovernmental Panel on Climate Change's (IPCC) A2 scenario, originally considered a relatively high emissions case, but which conforms reasonably well to observed increases in CO_2 emissions since the year 2000. Figure 4 is based on the IPCC's A1B scenario because projections of seasonal depth of thaw or freeze are not yet available for the A2 scenario.

- **Air Temperature** (Figure 1) – In general, annual temperatures in Arctic Alaska are projected to rise during the 21st century, increasing by 5-6°F by mid-century (2050-2059) compared to the baseline period (1960-1989), and by 11-14°F by end of the century (2090-2099). Most of this warming will occur during winter (October-May) and is expected to affect coastal areas more than inland areas.

- **Precipitation** (Figure 2) – By mid-century, overall annual precipitation is expected to increase by 17-25%, and up to 50% by the end of the century, compared to the baseline period. Most of this increase is expected to occur in winter, thereby contributing to a deeper snowpack. Projections for precipitation are, however, subject to greater uncertainty than temperature projections.

- **Length of growing season** (Figure 3) – Growing season length is projected to increase across all Arctic Alaska ecoregions 11-13 days over baseline values by mid-century, and up to 25-32 days by the end of the century. These changes are primarily due to delayed onset of freezing in the fall, however earlier onset of the growing season in spring will also occur. Change in the length of the growing season also implies a change in plant phenology, which may affect forage quantity and quality available to herbivores at critical life history stages. Other changes in seasonality – delayed onset and earlier end of snow season, delayed freeze-up and earlier break-up of rivers, etc. – will also be of consequence to a wide range of fish and wildlife life history events and human activities.

- **Depth of active layer and seasonal frost** (Figure 4) – Arctic regions of Alaska are underlain by deep, cold, and continuous permafrost which is expected to warm over the century, as evidenced by a projected deepening active layer. While permafrost is expected to remain present throughout most of the Arctic well into the future, changes in the depth and character of the active layer could alter local drainage patterns, lake, pond, and wetland persistence and vegetation communities.

- **Surface moisture** – Future tendencies toward drier or wetter surfaces depend on the balance between precipitation and evapotranspiration. Increasing summer temperature and a longer frost-free period are expected to result in an increase in evapotranspiration, potentially outweighing increased precipitation and resulting in a net drying regime in the summer months. This is an active area of research and modeling, and there is uncertainty about whether surface conditions will be drier or wetter in the Arctic, and by how much.

Terrestrial Habitat Change

Figures 5-8 are graphical models of potential ecosystem response to warming, from the report "*Wildlife Response to Environmental Arctic Change: Predicting Future Habitats of Arctic Alaska*"[2] (WildREACH), prepared following a November 2008 workshop in Fairbanks. The entire report is available at http://arcticlcc.org/resources/
The figures compare current and projected habitat conditions for four arctic landscapes: coastline, coastal plain, foothills, and floodplains.

- **Arctic Coastline** (Figure 5) -- The combination of a longer open water summer period, sea level rise, and increased ocean and air temperatures is expected to result in accelerating rates of coastal erosion, particularly in areas of ice-rich permafrost. A longer open water period in the marine system will increase the frequency of storms occurring when unprotected coastline is more vulnerable to erosion. Less ice equates to longer fetch, and thus larger storm-driven waves and surges. If these processes result in a reduction in size and/or continuity of the barrier island system that is present along much of the Chukchi and Beaufort sea coasts, then the physical and biological attributes of the lagoon systems could shift toward a more oceanic environment. However, we remain uncertain of the dynamics between emerging oceanic conditions and barrier island erosion vs. accretion. The combined effects of increased coastal erosion and storm events that inundate coastal areas will result in lake drainage and salinization of coastal tundra.

- **Arctic Coastal Plain** (Figure 6) – Warmer and wetter conditions would have a strong effect on the stability of ice wedges that are common features across much of the North Slope. Melting ice wedges result in drying polygon centers and deepening troughs, over decadal time scales. In areas with sufficient topographic gradient, deepening troughs can develop into a drainage network that promotes runoff, lowering the water table. The net result may be conversion of many low centered polygons into high centered polygons. Lakes in this region tend to expand in surface area, as warmer temperatures and increased duration of the ice-free season contribute to shoreline erosion. Lakes may become more vulnerable to sudden drainage events, due to a variety of mechanisms: 1) expansion across a topographic barrier, 2) down-cutting of a new

[2] Martin, Philip D., Jennifer L. Jenkins, F. Jeffrey Adams, M. Torre Jorgenson, Angela C. Matz, David C. Payer, Patricia E. Reynolds, Amy C. Tidwell, and James R. Zelenak. 2009. Wildlife Response to Environmental Arctic Change: Predicting Future Habitats of Arctic Alaska. Report of the Wildlife Response to Environmental Arctic Change (WildREACH): Predicting Future Habitats of Arctic Alaska Workshop, 17-18 November 2008. Fairbanks, Alaska: U.S. Fish and Wildlife Service. 138 pages.

drainage channel associated with high-volume spring runoff (from greater snow volume), and 3) tapping by new polygon trough drainage networks. Drier soil conditions, reduced surface water, and interrupted stream flow are all possible outcomes if water balance (precipitation minus evapotranspiration) tends toward a drying regime.

- **Arctic Foothills** (Figure 7) – Hillsides are vulnerable to thermokarst thaw slumps, which: (1) expose new soil to plant colonization (including possible colonization by invasive species or species undergoing climate-associated range expansions); (2), increase sediment runoff into freshwater systems; and (3) cause ponding in the slumped area. Degradation of ice wedges on sloping terrain is expected to result in new and deeper gullies, and associated drying of lakes and intervening ridges. In the 20% of the Arctic foothills where massive ice (yedoma) exists, subsidence associated with thawing ice may create new ponds and lakes, but perhaps on a century time scale. Warmer summer temperatures are expected to be accompanied by higher primary productivity and consequent changes in plant community composition (noting that warmth-induced proliferation of *Sphagnum* moss may actually lower productivity in certain circumstances). Foothill slopes are the settings in which most shrub increase has occurred, and this trend is expected to continue. Drier soil conditions could result from the combination of a deeper active layer, better developed drainage networks, and increased rates of evapotranspiration (but, as noted above, it is unclear whether increased precipitation could compensate for these effects). A shift toward drier soils would increase the probability of tundra fires and interrupted stream flow during periodic drought conditions.

- **Floodplains** (Figure 8) – The response of riverine systems to climate change depends on water balance. Under drying conditions, channels will tend to stabilize and shrub cover will increase. Under wetter conditions, increased flooding, sedimentation, and prevalence of productive early successional vegetation may be expected. Floodplain systems are sensitive to the occurrence of extreme flood events, so a change in average precipitation may be less consequential than a change in frequency of extreme precipitation events, for which we have no projections. Absent increased precipitation, sediment loads could still increase as a result of temperature-influenced thermokarst events. Any increase in sediment transport could affect sedimentation rates on coastal deltas, as well as nutrient flow into deltaic systems. Floodplains provide corridors for expansion of alder and poplar, and perhaps other colonizing plant species.

Other Potential Climate-Driven Ecosystem Changes

In addition to changes in habitat structure and function outlined above, a wide range of climate-driven ecosystem and/or fish and wildlife population effects are hypothesized.

- **Contaminants** – Mobilization of sequestered contaminants, especially mercury, is expected to increase with permafrost thaw, increased fires and thawing glaciers.

- **Interspecific Trophic Relationships –** There may be changes in the availability of prey or forage, both in abundance, quality and timing of availability, that could affect the health and productivity of animals dependent upon those resources.
- **Interspecific Competitive Relationships –** Plant and animal community assemblages in the Arctic (including pathogens and insect pests) are likely to change under future climate scenarios. Warming conditions will be favorable to range expansion by some species, likely to the detriment of others.
- **Direct Climate Effects on Plants and Animals –** Climate can have direct physical and physiological effects on plants and animals. For example, such climate effects as increased occurrence of ice-on-snow, or temperatures outside of species optimal range, could affect wildlife and fish populations, respectively.

Climate Effects on Human Communities

While the exact effects of changing climatic factors on human communities cannot be predicted, some examples include:

- Community water supplies may be affected by changes in the timing of snowmelt, changes in precipitation, and increased sediment in streams and rivers (due to change in the active soil layer).
- Changes in fish and wildlife species distribution and abundance, life history events, and behaviors could affect subsistence success and create the need for changes in subsistence practices.
- Subsistence food storage may be affected by warmer fall temperatures, wetter summer weather, and increasing soil temperatures.
- Access to subsistence resources may be affected by changes in snow season, icing events, freeze-up, storms and wind events, and other changes in the physical environment.

Additional Changes in the Arctic (Non-Climate Factors)

In addition to climate-driven changes in the Arctic ecosystem, future land and resource management decisions will be affected by other changes not as directly related to climate. Some of these parameters and potential future conditions and considerations include:

- **Human population –** Population in the combined North Slope Borough and Northwest Arctic Borough census areas is projected to modestly increase from 17,041 in July 2010 to 18,733 in July 2035 (an average annual increase of 0.36%).[3]

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[3] Source: Alaska Department of Labor and Workforce Development, Research and Analysis Section, Alaska Population Projections 2010-2035.

- **Subsistence resource use –** An increase in human population on the North Slope will likely result in increased demand for subsistence foods. However, climate-driven changes may cause changes in the overall composition of the subsistence diet.
- **Resource development –** While global markets, technology and other factors will influence resource development patterns and activity, there is expected to be significant interest in future resource development in the circumpolar Arctic, primarily driven by oil and gas potential.
- **Infrastructure –** Additional resource development infrastructure is likely, but its amount and location is unknown. In addition, a growing human population in the Arctic would require additional community infrastructure.
- **Maritime traffic –** Maritime traffic through the Bering Strait and Chukchi Sea within the US Exclusive Economic Zone (EEZ) has risen with the growth in ecotourism, ore and petroleum transport and support shipping.[4] Arctic marine traffic is projected to increase gradually over the next 10-20 years.[5]

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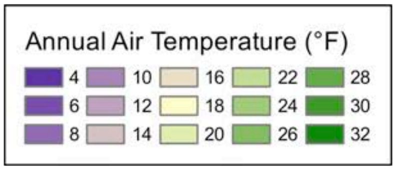
[4] NOAA Sea Ice Forecsating Workshop Summary, 19-21 Sept 2011, Anchorage AK. PDF available at http://www.arctic.noaa.gov/

[5] Source: Hinrichs, Kayla. Sept. 2012. Arctic: Assessments and Projections – Commercial Activity and Future Trends.



Ecoregion	2010-2019		2039-2039		2050-2059		2090-2099	
	Avg.	Chg.	Avg.	Chg.	Avg.	Chg.	Avg.	Chg.
Beaufort Coastal Plain	13.5	2.8	14.3	3.5	16.6	5.8	23.9	13.1
Brooks Foothills	15.5	2.6	16.2	3.3	18.3	5.3	25.4	12.5
Brooks Range	17.6	2.4	18.3	3.1	20.1	5.0	26.7	11.5

Chg. = Change from baseline (1960-1989).

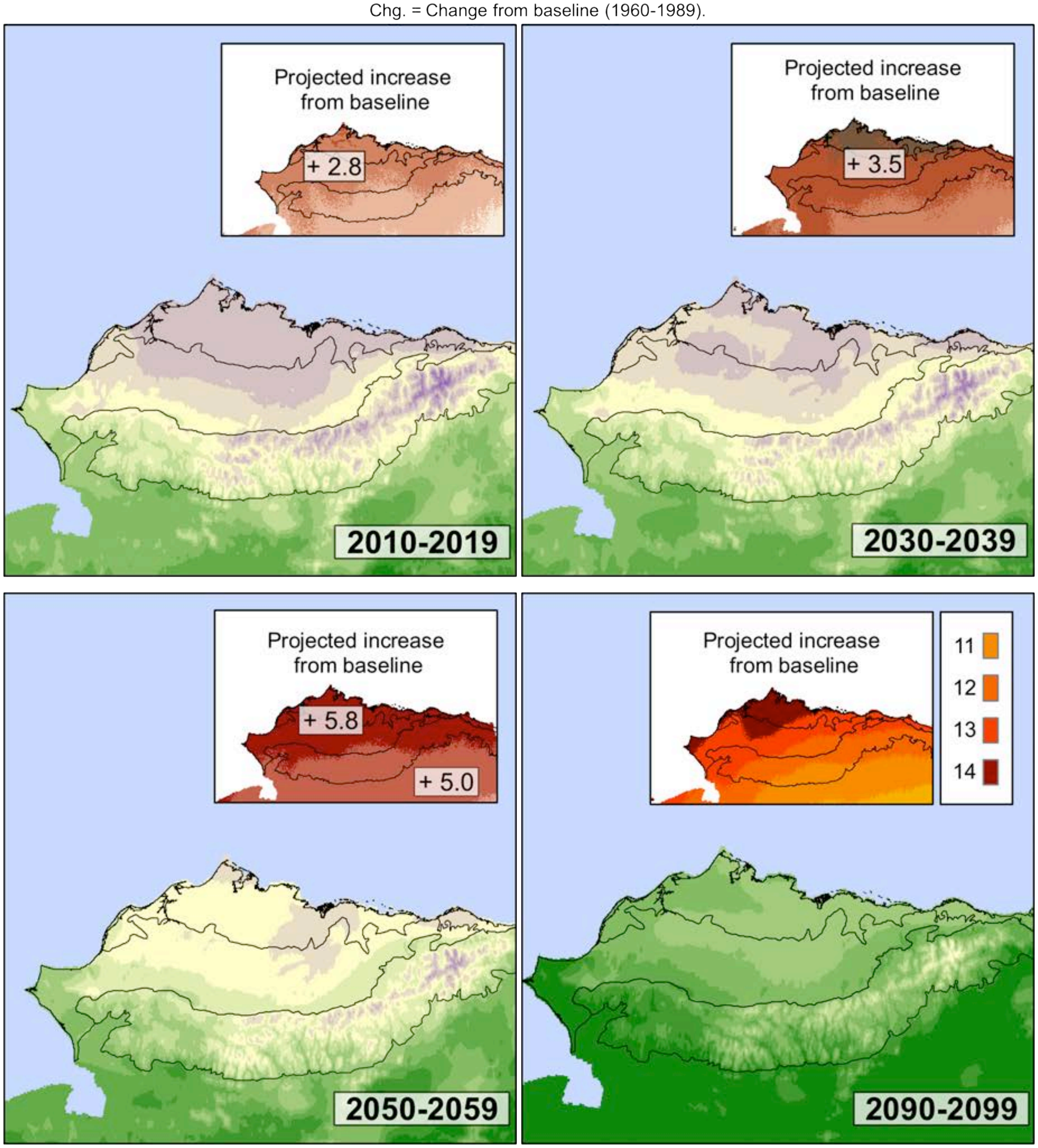
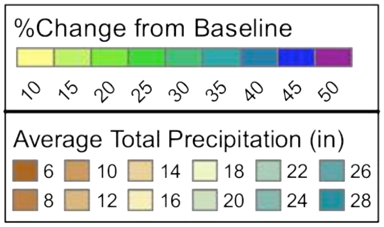


Figure 1: Change in annual air temperature (°F). Map created by Arctic LCC staff. Data provided by Scenarios Network for Alaska & Arctic Planning (SNAP): Historical Monthly Average Temperature 2km CRUTS3.0/3.1; Projected Decadal Averages of Annual Mean Temperatures 2km AR4 - **A2** scenario. Ecoregions (Nowacki et al.) shown in black.



Ecoregion	2010-2019		2039-2039		2050-2059		2090-2099	
	Avg.	%Chg.	Avg.	%Chg.	Avg.	%Chg.	Avg.	%Chg.
Beaufort Coastal Plain	8.7	12.6	9.0	16.2	9.7	24.0	11.7	50.6
Brooks Foothills	12.3	11.2	13.0	16.1	13.7	23.3	16.8	50.6
Brooks Range	18.5	10.7	19.2	14.3	20.4	21.7	24.6	46.2

Avg. = Average annual total precipitation (inches)

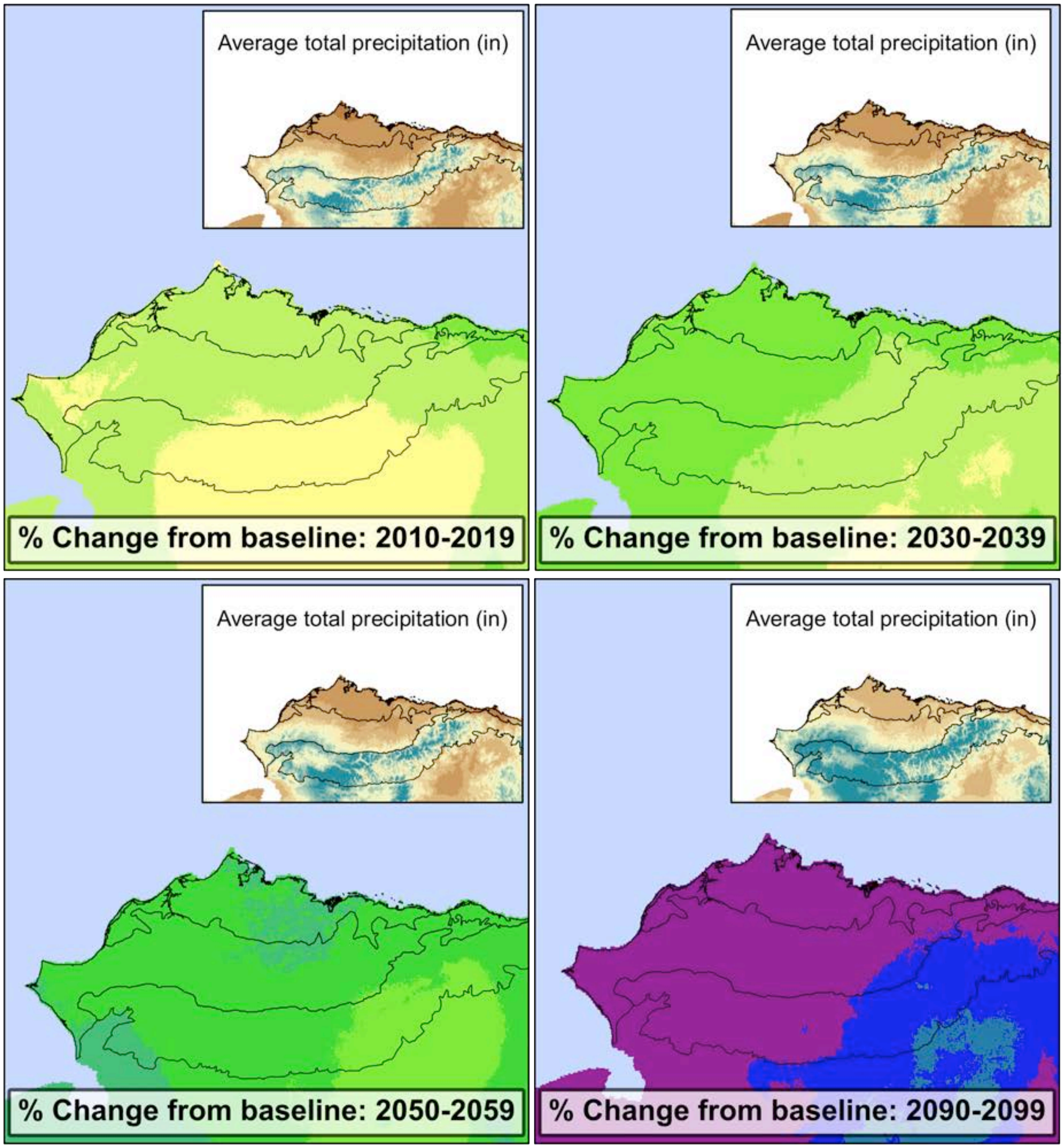


Figure 2: Change in annual total precipitation. Map created by Arctic LCC staff. Data provided by Scenarios Network for Alaska & Arctic Planning (SNAP): Historical Decadal Averages of Annual Total Precipitation 2km CRUTS3.0/3.1; Projected Decadal Averages of Annual Total Precipitation 2km AR4 - **A2** scenario. Ecoregions (Nowacki et al.) shown in black.

Ecoregion	2010-2019			2039-2039			2050-2059			2090-2099		
	Ch	T	F	Ch	T	F	Ch	T	F	Ch	T	F
Beaufort Coastal Plain	4	2	2	7	3	4	13	4	9	32	11	21
Brooks Foothills	4	3	1	6	3	3	10	4	6	26	11	15
Brooks Range	3	2	1	6	3	3	10	4	6	25	12	13

Ch = Mean change in number of days from baseline (1960-1989); T = Advance of thaw; F = Delay of freeze.

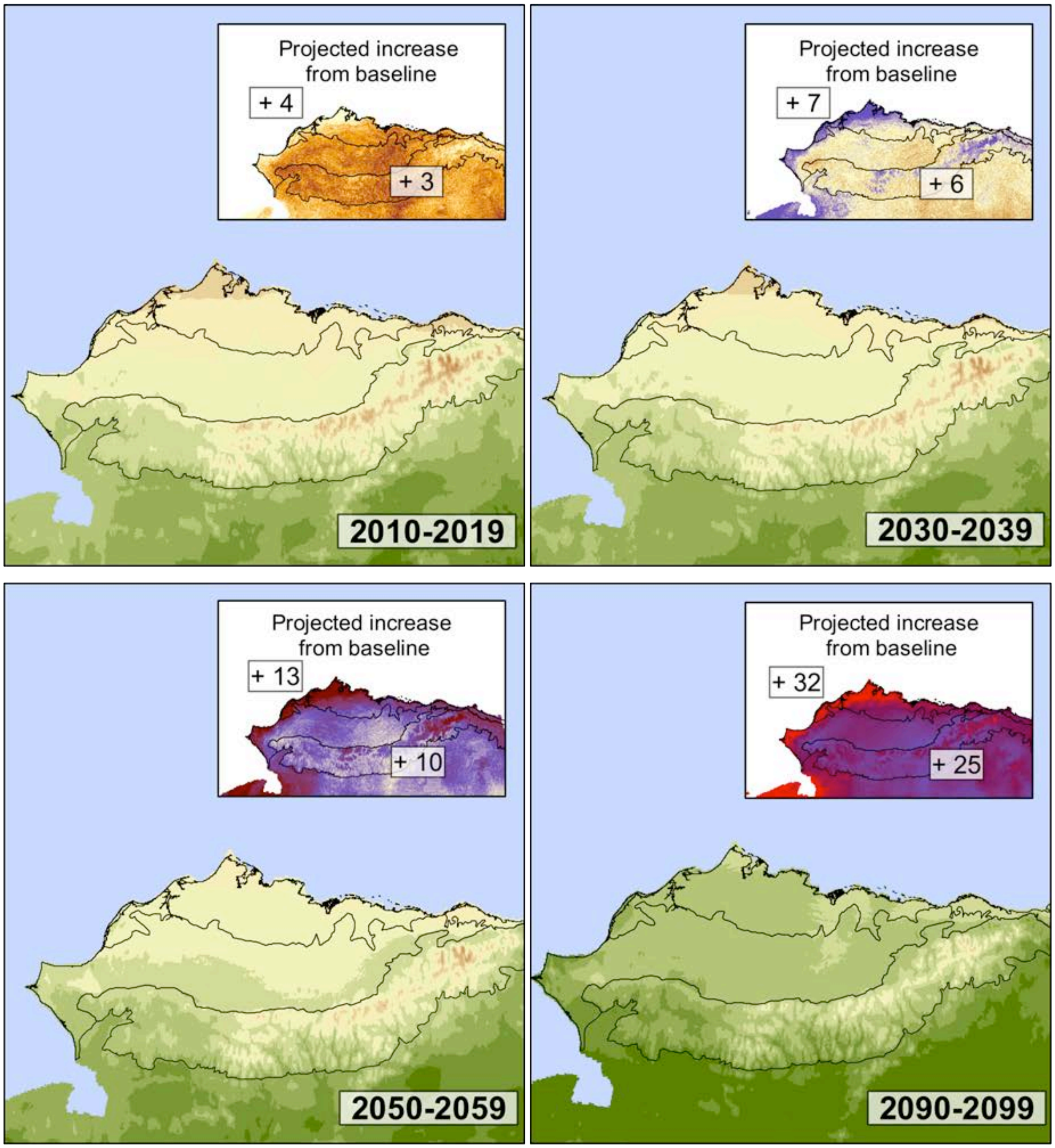


Figure 3: Change in growing season length (days). Map created by Arctic LCC staff. Data provided by Scenarios Network for Alaska & Arctic Planning (SNAP): Historical Length of Growing Season 2km CRUTS3.0/3.1; Projected Length of Growing Season 2km AR4 - A2 scenario. Ecoregions (Nowacki et al.) shown in black.

Active Layer Thickness or Seasonal Freezing Depth (inches)

Average, minimum, and maximum depth of active layer in three different Ecoregions.

Ecoregion	2010-2019			2039-2039			2050-2059			2090-2099		
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Beaufort Coastal Plain	16.3	7.5	27.9	17.1	8.2	29.5	17.6	7.5	31.3	22.0	11.1	42.7
Brooks Foothills	23.7	12.1	42.3	25.0	12.8	45.7	26.1	-	49.6	25.2	-	54.3
Brooks Range	26.5	6.0	50.0	28.4	-	54.4	30.0	-	62.1	19.3	-	56.7

A **dash** indicates that some portion of the Ecoregion has changed from a seasonally thawing to a seasonally freezing regime.

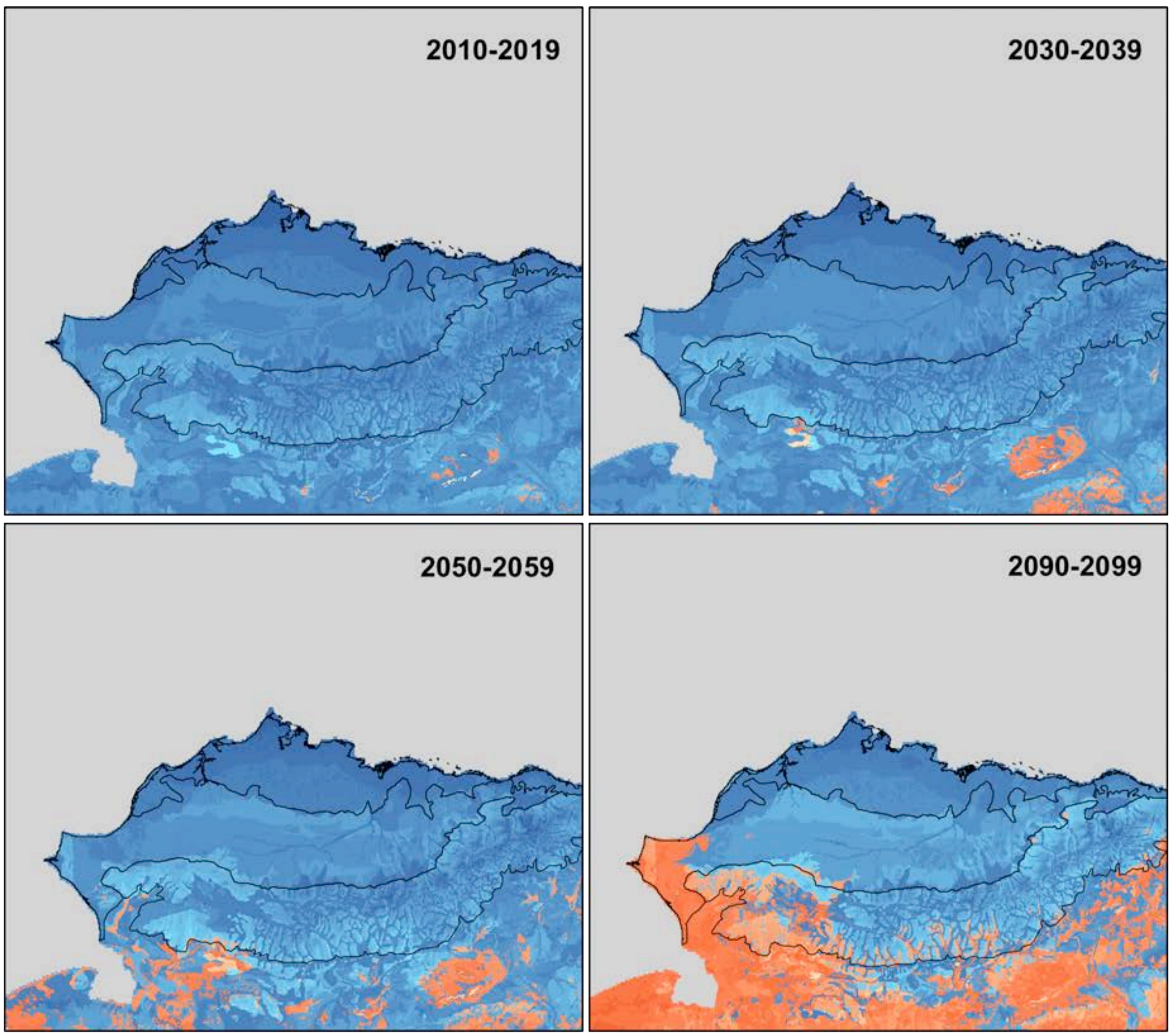
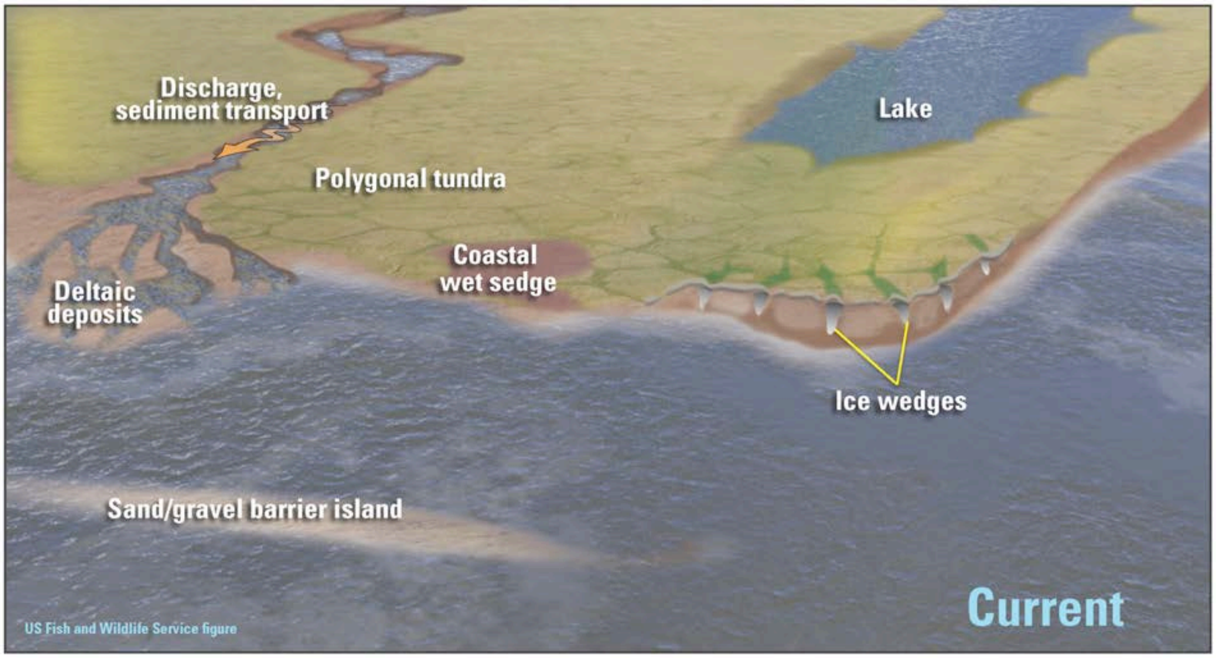


Figure 4: Active layer thickness or seasonal freezing depth (inches). Map created by Arctic LCC staff. Data provided by the Geophysical Institute Permafrost Lab (GIPL): GIPL1.3 Simulated Maximum Active Layer Thickness (ALT) in meters 2km - **A1B** scenario. Ecoregions (Nowacki et al.) shown in black.



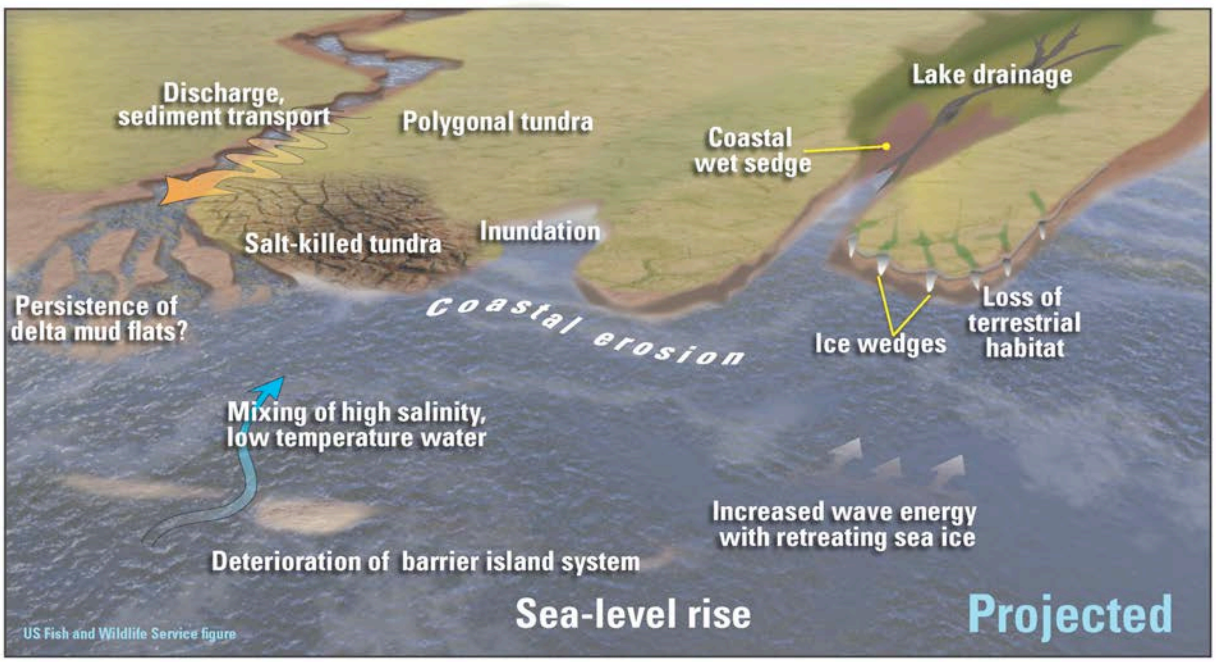


Figure 5. Schematic of Arctic Coastline landscape, current (above) and projected (below). The projected landscape illustrates elments likely to change as a result of climate warming.

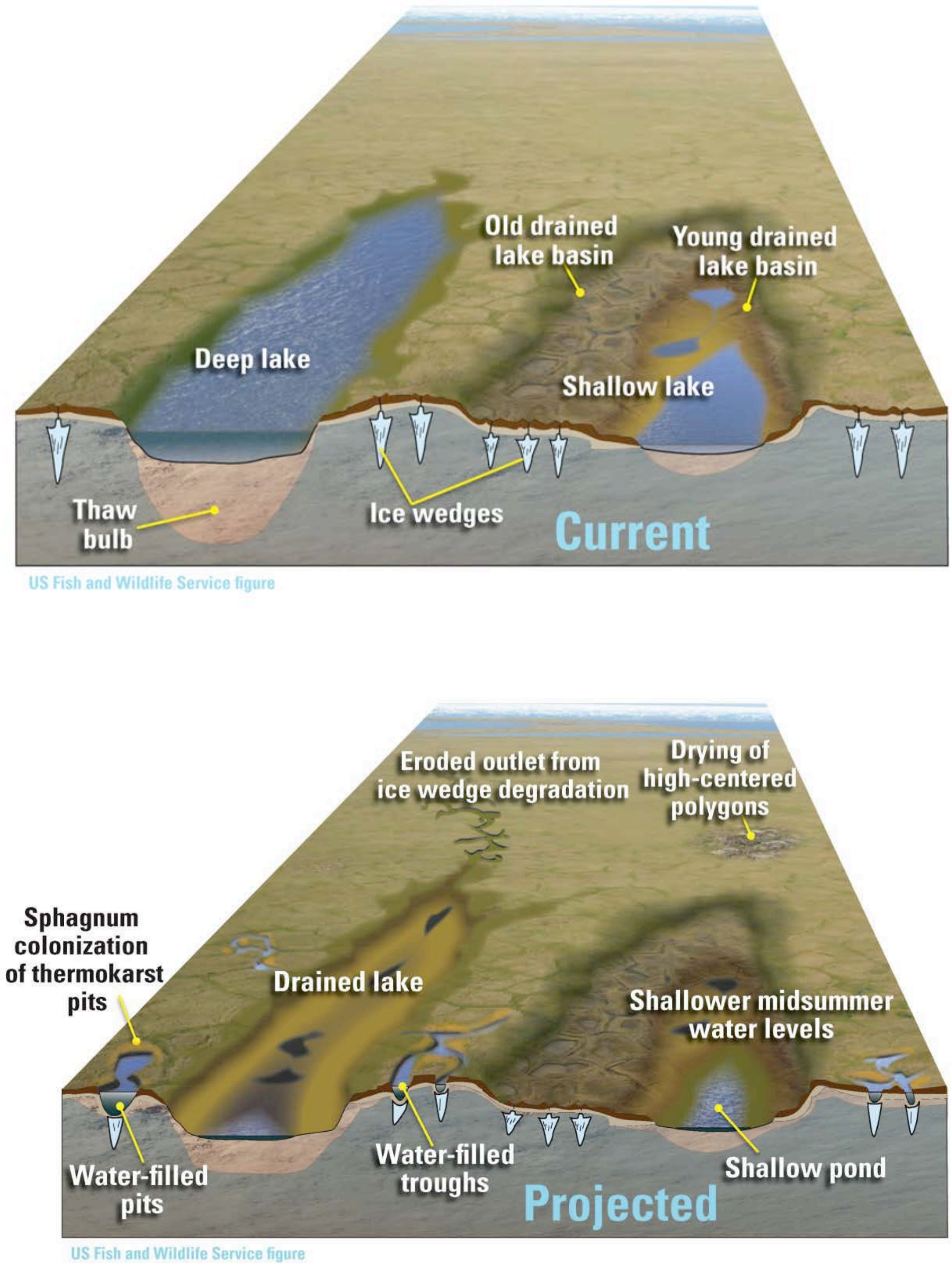


Figure 6. Schematic of Arctic Coastal Plain landscape, current (above) and projected (below). The projected landscape illustrates elments likely to change as a result of climate warming.

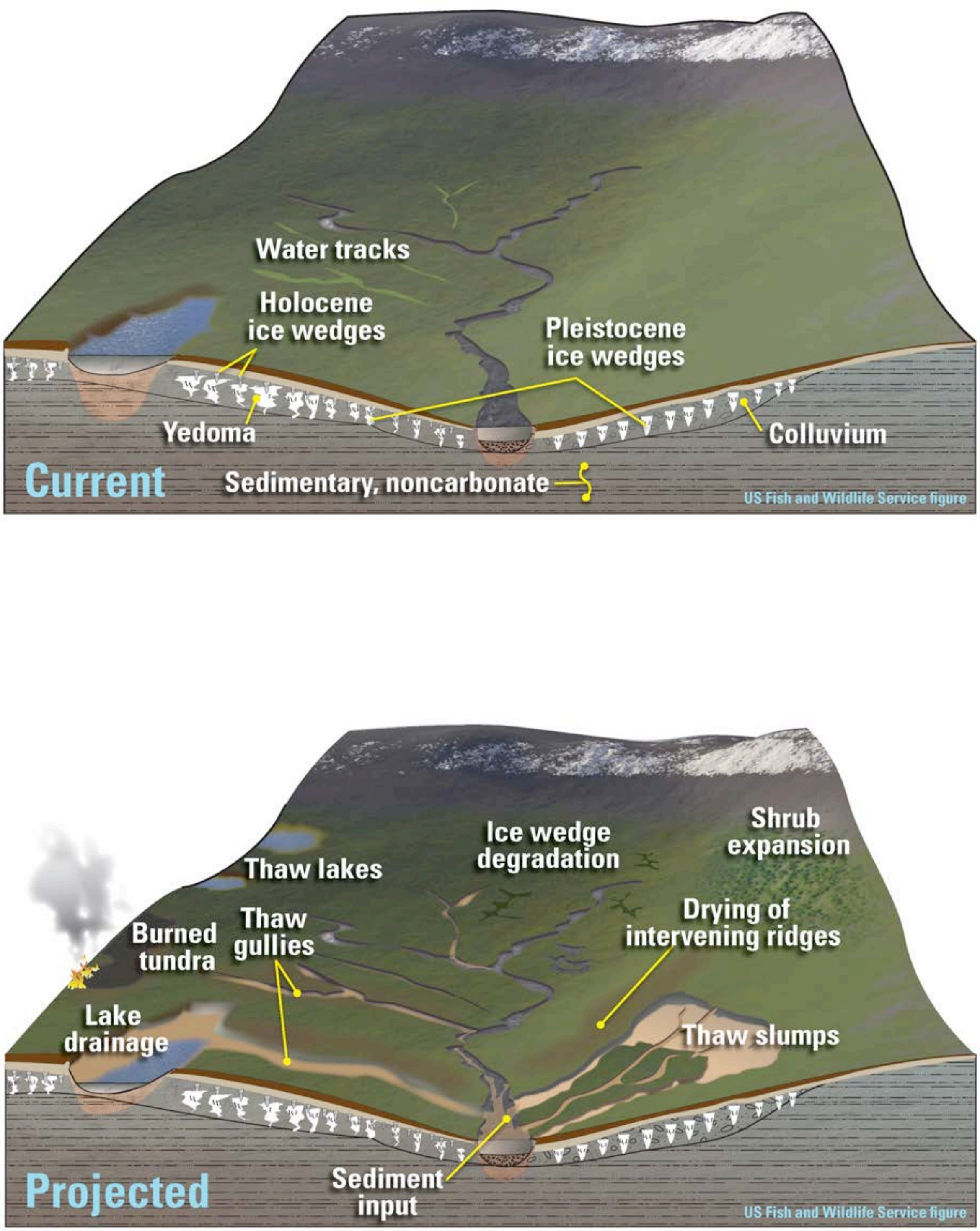


Figure 7. Schematic of Arctic Foothills landscape, current (above) and projected (below). The projected landscape illustrates elments likely to change as a result of climate warming.

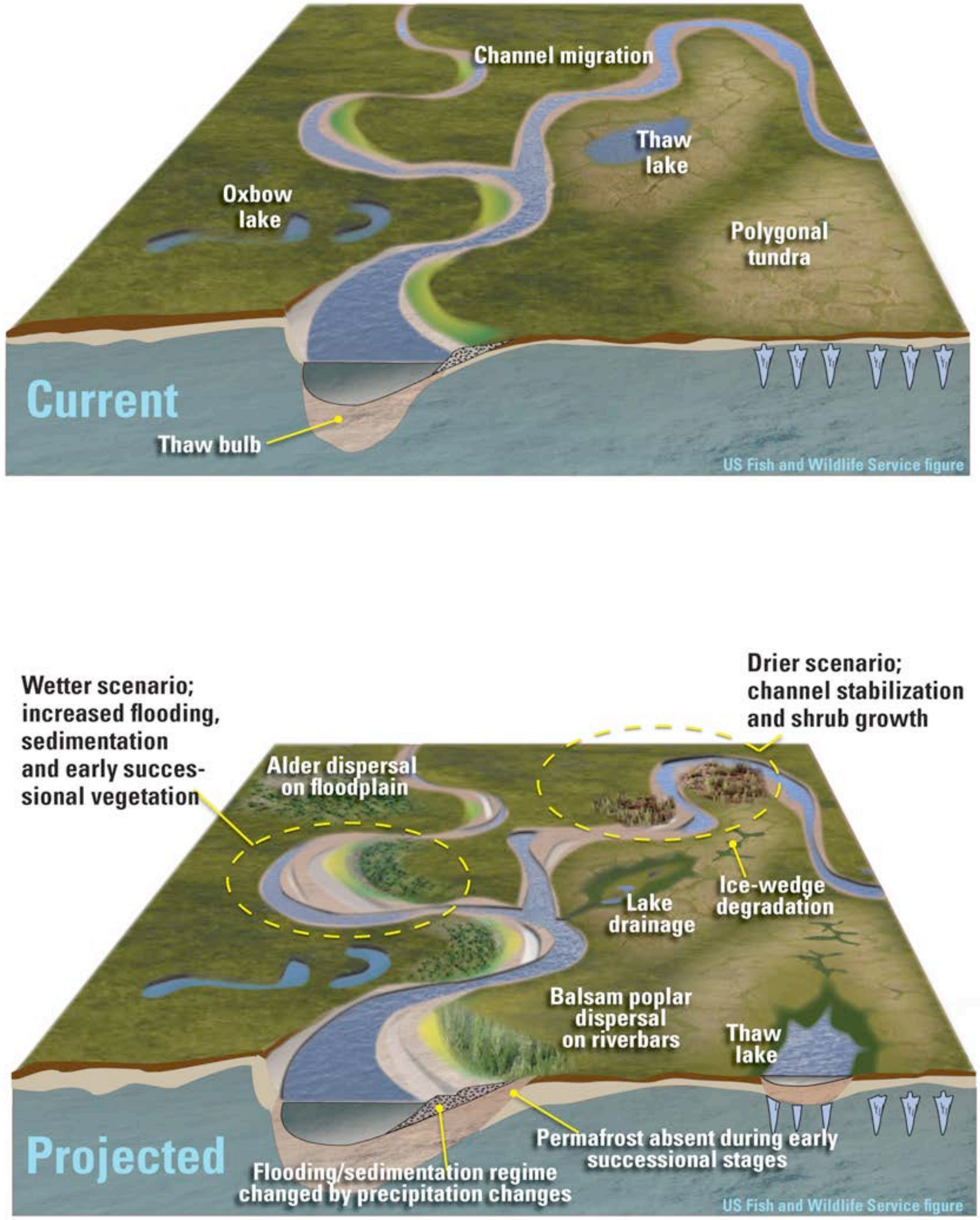


Figure 8. Schematic of Arctic Floodplain landscape, current (above) and projected (below). The projected landscape illustrates elments likely to change as a result of climate warming.

Summary of Interview Results

Appendix 2 provides a summary of responses provided by 27 federal, state and local government land and resource managers or researchers to the interview questions listed in Appendix 1.

The first section of Appendix 2 summarizes the response to interview questions 5-7 and is presented as a listing of 46 science and information needs, in four categories:

- Physical Parameters & Processes
- Biological Parameters, Processes, Responses
- Applied Information / Decision Support Tools
- Human Environment / Cultural Resources

The Steering Committee referred to this information as they ranked the science and information needs.

The second section of Appendix 2 summarizes the responses to all other interview questions. This information provides context for the Future Needs Assessment and addresses additional topics of interest to the LCC Steering Committee and staff (for example, what types of formats the land and resource managers find most useful for sharing scientific information).

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
Physical Parameters & Processes						
1	**Hydrology / Hydrography - baseline mapping of surface & groundwater dynamics & distribution; modeling, forecasting**	saltwater intrusion-habitat impacts fish & waterfowl habitat watershed mapping & changes ecosystem services (poorly understood) - such as water supply	21	3	15	infrastructure (permitting, siting, design, engineering, construction) habitat assessment, protection, mititation (esp waterfowl) fish and wildlife management (esp waterfowl) resource protection (e.g. spill response) protection of ecosystem services adaptation actions (habitat restoration) subsistence activities & management community planning community water supplies water allocation

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
2	**Coastal erosion - mapping, modeling, forecasting**	coastline location and stability changes in coastal habitats (e.g. coastal lagoons, river mouths)	18	10	8	Infrastructure (permitting, siting, design, engineering, construction) OCS management transporation system planning habitat assessment, protection, management community planning cultural resource management at-risk sites management (e.g. contaminants) resource protection (e.g. spill response) ecosystem restoration adaptation actions to protect features and habitats (e.g. armoring shoreline) park, wilderness, refuge, recreation management

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
3	**Sea ice - mapping, trend analysis, forecasting (and conversely, open water)**		15	5	8	habitat impact assessment, protection, mitigation infrastructure (planning, permitting, design, siting, engineering, construction) transporattion planning & management OCS management resource development permitting resource protection (e.g. spill response) marine mammal management endangered species management refuge management habitat restoration planning (e.g. post-spill) adaptation actions subsistence activities

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
4	**Permafrost (and soils) - mapping, modeling, forecasting**		13	6	8	infrastructure (planning, permitting, design, siting, engineering, construction) resource development planning, management, permitting habitat impact, assessment protection, mitigation transportation planning & management access management community planning community relocation subsistence activities
5	**Sea level rise / coastal flooding**		5	3	2	infrastructure (planning, permitting, design, siting, engineering, construction) habitat impact assessment, permitting, mitigation transporation planning & management subsistence activities community planning community relocation cultural resource management

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
6	**Ocean acidification**		5	2	2	OCS management habitat impact assessement, proteciton, mitigation marine mammal protection & management endangered species management fisheries conservation & management
7	**Weather - trends, storms, waves, extremes**	effects of weather on construction season effects of weather on infrastructure / communities	5	1	1	infrastructure (planning, permitting, design, siting, engineering, construction) habitat impact assessment, protection, mitigation transportation planning & management OCS management community planning manage at-risk sites (e.g. contaminants) cultural resource management
8	**Temperature - baselines, change, modeling, forecasting**		4	2	3	infrastructure (planning, permitting, design, siting, engineering, construction) habitat impact assessment, protection, mitigation transportation planning & management

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
9	**Air quality - Monitoring and modeling of air quality**	air quality modeling in relation to forecasted changes in weather and wind air quality impacts on human communities & species of interest (e.g. birds)	4	2	2	Infrastructure (permitting, siting, design, engineering, construction) OCS management transportation planning habitat assessment, protection, management
10	**Snow pack - depth, seasonality**		3	1	3	infrastructure (planning, permitting, design, siting, engineering, construction) transportaiton planning & access habitat impact assessment, protection, mitigation marine mammal management (e.g. ringed seal) endangered species management community planning
11	**Fire regime - modeling, forecasting**		3	1	1	fire management planning & response
12	**Glacier changes**		3	1	1	baseline information affects on water regime, riverine erosion, aquatic habitats

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
13	**Riverine erosion**		3	1	1	infrastructure (planning, permitting, design, siting, engineering, construction) habitat impact assessment, protection, mitigation transportation planning & management manage at-risk sites (e.g. contaminants) cultural resource management community planning
14	**Physical oceanography - currents, temperature, other paramters**		3	0	1	infrastructure OCS management habitat impact, assessment protection, mitigation resource protection (e.g. spill response) marine mammal protection & management endangered species management fisheries conservaton & management
15	**Precipitation**		2	1	1	infrastructure (planning, permitting, design, siting, engineering, construction) transportation planning & management habitat impact, assessment, protection, mitigation

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
16	**Nutrient cycling**		2	1	1	baseline understanding of ecological processes
17	**Water quality**	including sediment; heavy metals	2	0	2	habitat impact assessment, protection, mitigation resource development permitting
18	**Season length - freezeup, breakup, greenup date**		1	1	1	infrastructure (planning, permitting, construction) fire management
19	**Inland coastal plain physiography - modeling surface of inland coastal plain; effects on hydrology & surface water**		1	0	0	infrastructure (permitting, siting, design, engineering, construction)

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
Biological Parameters, Processes, Responses						
20	**Fish and Wildlife - status and trends for specific species**	FISH salmon sheefish TERRESTRIAL MAMMALS moose caribou Dall sheep snowshoe hares brown bears pica marmot lemmings MARINE MAMMALS seals (bearded, ringed, other) whales (bowhead) walrus polar bear BIRDS songbirds raptors snowy owls OTHER prey species keystone species subsistence species sensitive species "priority species LCC can agree on"	13	5	10	habitat impact assessment, protection, mitigation fish & wildlife management OCS management subsistence management infrastructure (planning, permitting, mitigation) resource development permitting spill response restoration plans (post-spill) marine mammal management endangered species management migratory bird management park & refuge management

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
21	**Fish and wildlife - effects of environmental change on fish and wildlife habitat use patterns**	habitat use, including migratory corridors Kernel analysis and use areas "what is prudent amount of acreage [and its distribution] to protect for selected species of concern?"	10	1	3	habitat impact assessment, protection, mitigation fish & wildlife conservation and management subsistence management fire management response planning (e.g. spill response) adaptation actions (e.g. habitat enhancement) marine mammal management endangered species management migratory bird management park, refuge management infrastructure (planning, permitting, mitigation) transporation planning & access management
22	**Plant communities - predicted shifts in distribution and composition**	important if approaching a line with critical habitat for some species changes in shrub component	7	0	5	habitat impact assessment, protection, mitigation fire management response planning (e.g. spill response) adaptation actions (e.g. habitat enhancement)

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
23	**Explore and describe linkages between physical drivers and biological responses**	need "wise choices" on which physical drivers are most important to test and which biological responses to examine "hard to get support for these types of studies in an agency"	4	3	0	habitat impact assessment, protection, mitigation fish & wildlife management
24	**Invasive species**	emphasis on marine aquatics	4	0	3	habitat impact assessment, protection, mitigation fishery conservation & management OCS management
25	**Fish and wildlife - changes in behavior, phenology**	can effect fish and wildlife health, sustainability timing of caribou migration affect subsistence harvest access & success	3	1	2	habitat impact assessment, protection, mitigation fish & wildlife management subsistence management subsistence activities Fish and wildlife - changes in behavior, phenology

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
26	**Coastal / nearshore ecosystem ecology**	coastal lagoon habitats changing river mouths	3	0	0	habitat impact assessment, protection, mitigation fishery conservation & management migratory bird management refuge management - wildlife, access, zones of use, capacities, impacts, Wilderness mgt. spill response restoration plans (e.g. post-spill) adaptation actions - habitat enhancement
27	**Fish assemblages**	sheefish whitefish species of fish using coastal lagoons	2	0	0	vital sign monitoring fishery conservation & management
28	**Small mammal assemblages**		1	0	1	vital sign monitoring habitat impact assessment, protection, mitigation
29	**Alpine ecology**	focus has been on coastal areas; lack data in western LCC	1	0	0	habitat impact assessment, protection, mitigation

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
Applied Information / Decision Support Tools						
30	**Arctic engineering - research to inform how to design and construct infrastructure to withstand changing climate (e.g. permafrost changes) & to minimize habitat impacts**		8	3	0	infrastructure permitting (design, siting, mitigation) review adequacy of engineering for changing climate OCS management community planning
31	**Modeling & forecasting; evaluation of the predictions over time**	Evaluate rate of change of key parameters - observed data, hind-casting, evaluating forecast accuracy	6	2	0	support management decisions
32	**Downscaled modeling - Models at sub-region or local area scale**		3	2	0	support management decisions
33	**Outreach - policymakers, public**	"break information down to be digesitible to our residents and for use in policy decisions"	3	1	0	support management decisions

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
34	**Adaptation actions - Scenario planning to inform future adaptation actions (related to biological resources)**	test adaptation scenarios (e.g, for polar bear, migratory birds)	2	0	0	marine mammal protection act - harvest, protection & management endangered species management migratory bird management refuge management
35	**Data portal - integrated, cross-agency data storage and access**		2	0	0	support management decisions
36	**Planning tools (for communities) that address climate change issues and effects**		1	1	0	community planning
37	**Protocol for cross-boundary inventory and monitoring (e.g. Porcupine caribou)**		1	1	0	inventory and monitoring wildlife management subsistence management
38	**Trend analysis - to support decisions/stipulations /mitigation & monitoring that are adaptive to expected changes**		1	1	0	support management decisions

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
39	**Protocols for factoring climate change into NEPA processes - providing training**		1	0	0	NEPA processes
40	**Risk management - guidance for managers with determining risk and consequences**		1	0	0	support management decisions
Human Environment / Cultural Resources						
41	**Community subsistence harvest - systems, change**	noted importance of traditional knowledge	7	2	4	infrastructure (planning, permitting) subsitence activities fish and wildlife management subsistence management community planning OCS management

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
42	**Human dimensions of change - effects on residents of the Arctic (demographics, community locations, areas of human use & activity)**	how will human communities in the Arctic change and adapt? changes in where people live and human activities occur how resource development and other human activities will change in the Arctic (e.g. shipping, infrastructure, etc) how will changes in Arctic effect resource development and associated infrastructure (type, location, timing)	6	3	0	marine mammal management endangered species management effects on subsistence / subsistence management habitat impact assessment, protection, mitigation infrastructure community planning

No.	SCIENCE/INFO NEED	COMMENTS about info need	NUMBER (of 27 people) who identified need	Number who identified need as one of 2-3 TOP PRIORITIES	Number who want STATUS & TREND of this information	EXAMPLES/TYPES OF MANAGEMENT ACTIONS for which information needed
43	**Contaminants - baseline levels, risk**		3	0	2	infrastructure (planning, permitting) transportaiton planning habitat impact assessment, proteciton, mitigation spill prevention & response
44	**Cultural Resources - Identify & expand inventory of high risk cultural resource areas**		2	0	1	cultural resource protection
45	**Point source human effects on Arctic environment (e.g., communities, industrial sites, transportation corridors)**		1	0	1	vital sign monitoring habitat impact assessment, protection, mitigation
46	**Infrastructure conditions and replacement needs**		1	0	0	formulate recommendations on how federal funding should be spent in the Arctic

Arctic Landscape Conservation Cooperative

Summary of Additional Interview Responses

NOTE – Attachment 2: "Arctic LCC Science and Information Needs to be Ranked" presents responses to interview questions 5-7.

1. **What types of resource management decisions does your organization make in Alaska's Arctic on a regular basis now?**
   - Land, water and resource management
     - Leasing, permitting, stipulations, mitigation
     - Land and resource planning, allocation, zoning
     - Land and resource retention or disposal
     - Water allocation
     - Access permitting
   - Habitat management and protection
     - Habitat conservation
     - Air, land and water quality standards
     - Fire management and response
     - Contaminants – prevention, response planning and implementation, remediation
   - Species conservation, protection, enhancement, management and use
     - Endangered species management
     - Marine mammals management
     - Migratory birds management
     - Other fish and wildlife management
     - Harvest management, including subsistence
   - Planning and decisions about infrastructure and development (community, resource development related, transportation, other)
     - Engineering and design
     - Location
     - Permitting
     - Assessment and mitigation of impacts
   - Cultural resource management and protection
   - Wilderness management (direct and indirect impacts)
   - Recreation management
   - Recommendations about Arctic research priorities

- Law enforcement decisions
- (Noted that not all parties interviewed were land or resource managers. Several were research agencies that generally responded based on their knowledge of what managers' have requested.)

2. **Thinking ahead up to 30 years in the future, to what extent and in what ways do you expect projected climate-driven changes in the Arctic to affect the types of decisions your agency will be making?**
    - Interviewees do not expect major changes in the types of decisions (unless new mandates or requirements are enacted in response to emerging issues)
    - Expect significant changes in the number of decisions, pace at which decisions must be made (urgency), the outcomes, and which types of decisions are determined to be priorities for agency action
    - Expect increased need to focus on: infrastructure design, location, permitting; resource development projects; subsistence management; endangered species management and recovery planning; other species/resources considered to be of highest value to those promulgating statutes and regulations (e.g., mega-fauna, indicator species)
    - Possibly more litigation if there are real or perceived resource scarcity or harm
    - May be different resources and issues to consider (e.g. if species expand range into Arctic)

3. **How important do you expect climate-driven changes to be in influencing your agency's future management in the Arctic, compared to other non-climate factors (such as changes in human population, subsistence needs, resource development, infrastructure, maritime traffic, or other factors)?**
    - Majority of those interviewed believe that climate-driving factors will have an influence on future management (from important, to very important, to most significant)
    - However, many noted that many "non-climate factors" are also influenced by climate (e.g. resource development & maritime traffic facilitated by changes in sea ice) – factors are linked
    - Several noted that they expect non-climate factors will be a bigger driver of their decisions and decision-making

    If you think that non-climate factors will significantly affect your agency's future management in the Arctic, which non-climate factors to you expect will be most significant?

    Most frequently mentioned:

    - Resource development, particularly oil and gas (mentioned in 20 interviews)

- Demand for resource development-related and community-related infrastructure (e.g., pipelines, roads, ports) (12 mentions)
- Changes in subsistence uses and needs (8)
- Increasing maritime traffic (7)

Others mentioned:

- Increasing human population
- Rural Alaska economy – costs of goods
- Competition for fish and wildlife resources / increased access for harvesting
- Tourism
- Commercial fishing (if access is opened)
- International resource management initiatives and demands
- Increasing aircraft use
- Increased litigation

4. Do you take climate change information into account now, in your agency's <u>current management</u> decisions?

Nearly all of those interviewed indicated that they take climate change into account to some extent in their current management decisions.

If No – Why not? (For example, is it because you believe climate effects are not relevant to your decisions at this time, because you don't find sufficient climate change information to be available, or other?)

Those few who do not take climate change into account indicated that it was due to more limited direction in their guiding regulations or code, or lack of confidence in forecasts derived from models. It was also noted that some decisions are for shorter-term uses or activities for which longer-term climate change is not relevant.

If Yes – What types of information related to climate effects on the landscape do you use?

- Permafrost modeling / soil active layer (7 mentions)
- Coastal erosion rates / change in coastline, river mouths / flooding (6)
- Ice and snow data & models (6)
- Models of vegetation change (3)
- Status and trends of: marine mammals, fish & shellfish, sea birds, plankton (3)
- Traditional knowledge regarding changing climate and environment (2)

- Thermal modeling (2)
- Arctic engineering – projections of how infrastructure would respond over time (2)
- Season length (freeze up, green up dates) (2)
- Models of fire regime change (2)
- Ocean currents (2)
- Ocean acidification (2)
- Physiography – near-term conditions and trends
- Climate models
- Historical weather conditions
- Ocean temperature
- Air temperature
- Physical oceanography
- Wave and storm data
- Hydrological change

5. **If you have not found sufficient climate change information to be available, what additional information would you like to have to address <u>current management</u> objectives and support management decisions? For each information need that you identify, indicate why it is relevant to your management objective or decision.**

   See Attachment 2

6. **Thinking ahead up to 30 years in the future, what are the most significant information needs related to climate-driven changes that you would like to have addressed to inform <u>future management</u> decisions? Think in terms of information that would help with management of human activities (e.g., cultural resource management, structural engineering in a changing Arctic environment), as well as natural ecosystem management. For each information need that you identify, indicate why it would be relevant to a future management objective or decision.**

   See Attachment 2

7. **Is it important to know the status and trend of physical and biological elements of the Arctic ecosystem? Why or why not?**

   <u>All</u> parties interviewed believe it is important track status and trend of physical and biological parameters.

If so, can you identify particular variables or parameters of interest to your agency?

See Attachment 2

Is either historical trend or forecasting more useful, or both?

Nearly all parties indicated that both historical trends and forecasting are important and useful. Of those who indicated a relative importance, the majority indicated that forecasting is most important. Four indicated that historical trends are more important (putting more trust in observation of past trends than in the predicted forecasted outcomes).

Several commented that scenario planning is also a useful tool. Looks at drivers that may be changing the future conditions, puts bounds on "what could reasonably happen" and then crosses several factors to create four future scenarios.

8. **As ecological systems change in the future, is your agency likely to: (1) intervene to try to preserve the status quo, (2) take no specific action with regard to the change that occurs, or (3) facilitate change through adaptation actions?[1] (Examples of adaptation might include developing and using alternative approaches to resource development, armoring stretches of shoreline, or designation of protected natural and cultural areas.) Or, do you think that it is premature to think about adaptation actions in the Arctic?**

    (1) Intervene to preserve status quo – 6 responses

    (2) No specific action – 8 responses

    (3) Facilitate change through adaptation – 17 responses

    Note that interviewees often indicated two or more of these courses of action, depending upon the future circumstances.

9. **If your agency is likely to take adaptation actions on a broad or site-specific scale, what might those actions be?**

    - Adapt facility design and siting; potential relocation (10 mentions)
    - Adapt mitigation measures to address social and ecological impacts (7)
    - Adapt permitting stipulations to address impacts (5)
    - Adjust management of human uses of fish and wildlife (4)

[1] "Adaptation" is defined by the Intergovernmental Panel on Climate Change (IPCC) as the "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploits beneficial opportunities." (IPCC 2007, Glossary)

- General “adaptive management” (4)
- Exclude area(s) or resource(s) from use for conservation purposes (3)
- Adapt fire management (2)
- Take action(s) to facilitate a species’ survival (2)
- Protect eroding shorelines
- Adapt community development plans/zoning

Thinking in terms of <u>future adaptation actions</u> that your agency might take, are there any other information needs related to climate change that your agency would have that you haven’t already mentioned above? For each information need that you identify, indicate why it would be relevant to support future adaptation actions.

Very few agencies offered any additional information needs in response to question #9 regarding future adaptation actions, so the responses were not compiled.

10. In what format would climate change information most usefully be provided to you? (Examples of formats that the LCC currently uses include provision of data sets, geospatial products, research reports, conferences or web presentations. Are these the most useful formats, or do you have other suggestions?)

Interviewees noted that there are many useful formats in which to provide information. Formats must be selected based on the purpose and the audience. Some general comments include the need to not duplicate what others are doing; importance of integrating information across disciplines. Suggested formats included the following (number of mentions indicated in parentheses):

- Geospatial products / geo-referenced data sets (17 mentions)
- Conferences / webinars (12) – suggestion that there be an annual conference re: projects funded by combined Alaska LCCs; interdisciplinary (however, also one strong suggestion that conferences/webinars are *not* valuable)
- “Raw” data sets, metadata (12) – web-based and/or searchable databases for accessibility
- Research reports – peer-reviewed, published, defensible – citable under NEPA and other statutes, defensible in court (10)
- Formats useful and informative to policy makers and general public (7)
- “Picture is worth a thousand words” (6) – animations, graphics, photos
- Geospatial / ecological models (5) – need to provide training in use & interpretation; make results clear to lay users, policy makers, public
- Tools useful to planners and managers, such as (5):

  - Predictive planning tools
  - Training on how to address climate change issues in NEPA analysis
  - Vulnerability assessments
  - Decision-support tools
  - "Downscaled" modeling information (service LCC provides)
- Traditional knowledge – communicate it and invite sharing (3)
- Noted in one interview that it is very important to bring information back to the communities (research is done in Arctic regions, but not adequately shared with communities through final reports, presentations, other products)

11. Thinking back on our discussion, what are your agency's top two or three information needs related to climate change that you would like the Arctic LCC to address? Why are these your highest priority for inclusion in the LCC's strategic framework?

See Attachment 2

GENERAL COMMENTS

The following general comments were also offered during interviews (not solicited through a specific interview question). Note that not everyone offered general comments, so this is not a "complete list" of what might have been on interviewees' minds.

- Must not duplicate efforts; look at things not being done well by others and put effort into those (4 mentions)
- Collaboration is key – Need to work in areas where there is a confluence of interests and many agencies can benefit from pooling funding and effort (3)
- Data synthesis and accessibility – don't duplicate efforts (3) – specific suggestions to pick one portal for Arctic data and make it function well
- Serve as forum for communication among agencies and other entities about what research is being done, what information is available, and how to access it (3)
- Facilitate development and use of a common strategy for inventory and monitoring for a core set of variables (among federal agencies) so data is compatible for use in future analysis (2)
- Help coordinate the various systems and processes across participating agencies. Doesn't know if best strategies are currently in place to work together across administrative lines (1)

- Do not attempt to be a forum for coordinating management – must be cognizant of management authorities (1)
- Essential to have communication with Arctic communities – present results, reports, other products back to Boroughs; involve Boroughs on LCC Steering Committee (1)
- Develop and provide training in decision-support tools – e.g. how to factor climate change into NEPA in a meaningful way (1)
- What is future funding picture for LCCs? If they are not sustained, is there a mechanism in place to make sure that the good work done to date is not lost? (1)
- Need to be cost effective, produce results relatively quickly to demonstrate value to partners (1)
- Scope – Adopt a strategic and reasonable geographic and physiographic scope (e.g., not Canada, not marine at this time) (1)
- Scope – Support LCC including marine work in its scope (1)
- Scope – need science/information for areas farther from the coast (1)
- Would be most useful for the LCC Requests for Proposals to be quite focused on key issues/topics (e.g. Western LCC focus on coastal storms and impacts to infrastructure) (1)
- Need to move beyond general baseline science, to identify a finite number of high-level questions regarding most vulnerable ecosystems and populations, then identify mitigation actions, monitor actions, adaptively manage (1)
- Make "wise choices" about which parameters to model and predict – link to key management issues and needs (1)
- For key baseline parameters, must define the baseline and the variation around the baseline, then project/forecast, and define the error in the models (1)
- On LCC website – provide opportunity for public to indicate what they think are the most important scientific issues for the LCC (and others) to address (1)
- Try to get additional, ongoing input from communities through due diligence / communication (1)
- Reach out to industry, non-government organizations, and Canada for their recommendations on science needs & priorities (1)
- Suggest school and/or citizen science projects (1)
- Suggest student award(s) to foster young scientists (1)
- Suggest there be a more concerted efforts by LCC to widely publicize annual Requests for Proposals (1)

Ranking Criteria

The following criteria were developed by the Arctic LCC Steering Committee and used to rank the 46 science and information needs listed in Appendix 2. The ranked results are presented in Table 1 of the Future Needs Assessment.

(NOTE – bullet points serve as examples that help in determining the score for each criteria; they are not sub-criteria that must all be satisfied or that would be individually scored)

Criterion #1 is a "Yes / No" filter. Science and information needs that are not relevant to the Arctic LCC's mission and goals will not be further evaluated against criteria #2-#7 and will not be included in the Future Needs Assessment.

1. **Mission/goals**
    - Relevant to the Arctic LCC's mission to "*identify and provide information needed to conserve natural and cultural resources in the face of landscape scale stressors, focusing on climate change*".
    - Relevant to the Arctic LCC's existing Cooperative Conservation Goals (August 2010):
        - *Better understand and predict effects of climate change and other stressors on landscape level physical and ecosystem processes.*
        - *Better understand the impacts of environmental change on subsistence and cultural resources.*
        - *Provide support for resource conservation planning.*
        - *Contribute to improved data management and integration.*
    - As described in the Arctic LCC's niche of operations outlined in its Cooperative Conservation Goals report and draft Science Plan, the initial efforts of the Arctic LCC will be within geographic areas influencing management issues in the Alaska terrestrial portion of the LCC. However, physical and ecological processes link terrestrial and marine systems and Arctic LCC interests will extend into the marine environment, particularly the nearshore zone. (It is noted that the LCC will continue to work with Canadian land-management authorities and other partners to expands its capacity to work internationally.)

Criteria #2 through #7 will be scored with a ranking of 0-5, with 0 indicating the criterion is not met and 5 indicating maximum score in meeting the criterion.

2. **Applicability to management (0-5)**
    - Provides useful information, tools and/or strategies that are applicable to and inform land and resource management activities.

3. **Scope (0-5)**
   - Relevant and important across a broad geographic and physiographic extent.
   - Addresses broad or interdisciplinary needs.
   - Addresses the needs of multiple organizations.
   - Addresses both cultural and ecological resource issues.
4. **Ecological and/or Cultural significance (score each bullet 0-5, then assign the *higher of the two scores* to criterion #4)**
   - Ecological - Improves understanding of how landscapes, habitats, or species respond to stressors, focusing on climate change.
   - Cultural - Applies or preserves historical or cultural knowledge (e.g. traditional knowledge, information about subsistence practices, cultural sites, or other information).
5. **Timeliness (0-5)**
   - Should be given higher priority to respond to a timely opportunity, such as to take advantage of significant additional outside funding sources or to collaborate with other entities.
6. **Contribution (0-5)**
   - Contributes to progress in meeting the Arctic LCC Science Plan.
   - Provides an important foundational step (building block) for addressing other needs.
   - Addresses question about which there is considerable uncertainty (e.g., not substantially addressed by other studies, existing data sets).
   - Contributes to needed landscape baseline data.
   - Contributes to needed long-term planning or monitoring.
7. **Feasibility (0-5)**
   - Can likely be addressed satisfactorily considering funding, complexity, technology, available expertise, time, and other realities of operating in the Arctic environment.

Arctic LCC Steering Committee
Future Needs Assessment
Meeting Notes

January 9, 2013

The Arctic Landscape Conservation Cooperative (LCC) Steering Committee met on January 9, 2013, in Anchorage to review results of the Future Needs Assessment, develop a final prioritized list of science and information needs from among needs identified in interviews with land and resource managers working in Alaska's Arctic region, and discuss how the prioritized list of needs will be used by the LCC.

Steering Committee members present: Doug Vincent-Lang, Alaska Department of Fish and Game (chair); Cheryl Rosa, US Arctic Research Commission (vice-chair); Catherine Coon, Bureau of Ocean Energy Management (BOEM), Amy Holman, National Oceanic and Atmospheric Administration; Anne Marie La Rosa, US Fish and Wildlife Service; Frank Hays, National Park Service (NPS); Jim Lawler, NPS; John Pearce, US Geological Survey (USGS); Mike Salyer, US Army of Engineers; Dee Williams, BOEM; Dave Yokel, Bureau of Land Management.

Others in attendance included Steve Gray, USGS; Philip Martin, Arctic LCC Science Coordinator; Jan Caulfield (facilitator) and Raquel Goodrich, Institute for Environmental Conflict Resolution.

Approval of the Future Needs Assessment, Ranked List of Science and Information Needs

At its January 9 meeting, the LCC Steering Committee directed that <u>the compiled rankings done by individual Steering Committee members will be used as the final list for the Future Needs Assessment report</u>. Committee members who had not yet done the ranking will be given another opportunity. All 46 science and information needs will be retained on the list.

The final list will also show key results from the interviews, including: number of interviewees who identified each need, number who identified a need as one of their top two or three priorities, and number who wanted status and trends data for each need.

Finally, the committee directed that science/information need #37 be edited to read "Methods for international cross-boundary inventory and monitoring".

The LCC staff and facilitators had expected that the Steering Committee would discuss and modify the initial list of science and information needs presented on January 9, which was a simple compilation of rankings done by seven Steering Committee members. Potential modifications might have included combining or renaming categories of needs, deleting some needs, and/or changing the order of priority.

However, after discussion, the Steering Committee reached consensus that it did not want to make changes to the list. They found the list to be useful in its current format, and did not think that potential benefits from developing a more-refined list merited the time and difficulty that might be involved in reaching agreement on changes.

Discussion of How the List Will be Used

The Steering Committee discussed how the Arctic LCC will use the prioritized list of information needs, and the value of the Future Needs Assessment. The group concurred with the following points:

- When the Future Needs Assessment was initially requested by the Steering Committee, it was recognized that the LCC was trying to address land and resource management needs, but hadn't done a formal assessment of needs. The assessment provided a process to consult with managers about their science needs, and see to what extent the LCC is responding to those needs.
- The process has been valuable and the list of needs validates the work that the LCC has been doing and the direction included in its other strategic documents. No major gaps were discovered between the managers' needs and the types of work that the LCC has undertaken and has considered in its strategic science planning.
- The needs list will help inform the LCC's decisions regarding what to include in Requests for Proposals, long-term monitoring processes, collaborations with other entities, and other programs of work.
- The Steering Committee agreed that the Future Needs Assessment list will "guide us, but not confine us."
- It is expected that LCC focus may be stronger on the needs at the top of the list, that those in the middle tier may receive less attention unless there are collaborative or other opportunities, and those at the bottom of the list may not receive attention due to other priorities and limited funding and capacity. However, the Steering Committee wants to retain all 46 needs on the list and wants to retain the flexibility to "reach down" and pursue needs that are lower on the list, if that is warranted in the future. If the Steering Committee wants to consider pursuing a need further down on the list, that would warrant more in depth discussion.
- The Future Needs Assessment list is just one strategic document that will guide the work of the LCC. Other strategic documents that provide guidance include the mission, charter, conservation goals, and recently approved science plan.

Relationship of the Needs List to the Strategic Science Plan

Philip Martin noted that there is general alignment between the top 25 needs on the list and the LCC's Science Plan. Socio-economic issues are included on the needs list, but are not as well addressed in the Science Plan as are other topics. Given the relatively high ranking of coastal processes, it may make sense to highlight this topic more in the Science Plan. No decision was made regarding any changes to the Science Plan to address these observations.

Observations about the List

The Steering Committee members offered the following observations about individual science or information needs on the list (unless otherwise indicated, the following points were made by a single committee member):

- If there was going to be some consolidation of needs on the list, the following could be grouped: #7 weather (trends, storms, waves, extremes), #8 temperature (baselines, change, modeling, forecasting), #10 snow pack (depth, seasonality), #15 precipitation, and #18 season length (freezeup, breakup, greenup dates). However, after discussion, the committee decided not to condense the list.
- Pleased that coastal erosion (#2) was ranked high on the list, as that fits within the LCC's focus on the near shore environment.
- In discussion of why downscaled modeling (#32) didn't rank high, it was noted that smaller scale modeling is not sufficiently precise. It was noted by another committee member that developing a more effective way to do downscaled modeling might be a LCC role. Another member indicated that they ranked downscaled modeling low because they thought it beyond the scope for the Arctic LCC.
- Reminder to the group to think beyond just the coastal plan, to include the full area to the south within the LCC's geographic boundary.
- In a discussion of outreach (#33), it was noted that it is important for the LCC to convey what is learned through projects that they fund, including providing information in a manner that non-scientists can understand.
- It was noted that only one of the needs within the top ten related to the human environment (#41 – community subsistence harvest – systems, change). However, three within the top 20 needs (including #42 human dimensions of change, and #44 cultural resources). It was noted that cultural resources may have different definitions for different management agencies.
- Surprised that #3 sea ice ranked as high as it did.
- For need #35 data portal, the words "integrated cross-agency storage and access" raises a scope and capacity issue. That is a huge beast that would be difficult for us to take on. In further discussion, it was noted that the LCC will archive all data for projects we fund and make that data accessible. Data is stored in compatible forms according to standards.
- Observation that more basic baseline data needs seem to be at the top of the list and more "derivative" topics are farther down the list.
- In discussion of the relationship of this type of list to the North Slope Science Initiative (NSSI) Emerging Issues list, it was noted that this list is narrowed to a climate focus.

- Observation that the committee members generally ranked lower topics that the LCC is not the most appropriate entity to address, such as changes in fire regimes, glacier changes, guidance related to how to address climate change in National Environmental Policy Act (NEPA) analysis.
- Surprised that #16 nutrient cycling did not rank higher.
- Suggestion (accepted by Steering Committee) that #37 be edited to “Standard methods for international cross-boundary inventory and monitoring” and that the example of “porcupine caribou herd” be deleted.

Next Steps

- Steering Committee members who did not participate in the initial ranking of information needs will be given another opportunity. The final list included in the Future Needs Assessment report will be the compilation of the rankings entered by individual Steering Committee members.
- Greg Balogh, LCC Coordinator and Philip Martin, LCC Science Coordinator will review the draft Future Needs Assessment report and work with the consultant to develop a final report. Steering Committee members do not need to review draft.
- The Steering Committee will receive a copy of the final report.
- Philip will add a paragraph to the Strategic Science Plan to reference the Future Needs Assessment and may append the final report to the Science Plan.