Northwest Boreal Forest (Formerly Northwestern Interior Forest) Landscape Conservation Cooperative

www.doi.gov/lcc/Northwestern-Interior-Forest.cfm
www.nwblcc.org (currently in development)

MANAGEMENT FRAMING WORKSHOP
October 30 – November 1, 2012
President’s Board Room, Yukon College, Whitehorse, YT

Workshop Summary
Wildlife Management Institute
www.wildlifemanagementinstitute.org
Brief overview of Landscape Conservation Cooperatives and NWB LCC

Amanda Robertson, NWB LCC Science Coordinator, gave a brief overview of Landscape Conservation Cooperatives, citing their purpose: Landscape Conservation Cooperatives (LCCs) are self-directed partnerships that provide science and support for conservation and sustainable resource management to address landscape-level challengers or stressors, such as climate change, that no one agency or organization could address alone.

NWB LCC is one of 22 LCCs in North America and the Pacific Islands, and includes the boreal and boreal transition zones in Alaska, Yukon Territory, western Northwest Territories and northern British Columbia. The NWB LCC partnership consists of federal agencies, provincial/territorial governments and agencies, Tribal and First Nations governments, non-governmental organizations, universities and others. LCCs recognize that many landscape-scale stressors transcend political and jurisdictional boundaries and require a more networked approach to conservation and sustainable management – holistic, collaborative, adaptive, and grounded in science. As self-directed partnerships, Steering Committees decide how each LCC will support applied science to inform landscape conservation in each LCC region.

The NWB LCC Interim Steering Committee formed in October 2011 with only Alaskan organizations, but it quickly evolved to include Canadian organizations devoted to the sustainable management and conservation of boreal ecosystems. At its quarterly meeting in May 2012, the NWB LCC Interim Steering Committee ratified its charter, and is no longer an interim committee. Currently, there are 20 federal, state/provincial, NGO and other organizations represented on the Steering Committee.

Framing workshop objectives

The NWB LCC is working with its partners to determine commonalities in what science and management information is needed, at what scale, and in what format, to inform but not direct) local (and landscape management and planning across the region. This Framing Workshop is the first of several workshops and meetings to identify shared information needs that will serve as the foundation of a science planning process. The workshop participants will begin defining science and management information end users’ needs that will help establish a decision context for future LCC activities. Examples of information end users include decision makers, policy makers, scientific researchers, and individuals from: government agencies, non-governmental organizations, Tribes and First Nations, local governments, universities, and the private sector.

Participants will identify shared information needs in a logical, consistent manner, following these steps:

1. Identify potential resource information end users
2. Identify outcomes that are of interest to users
3. Identify information needs
4. Develop criteria for evaluating the list of information needs
5. Prioritize science/information needs
When these five steps have been accomplished, the Steering Committee, other managers and scientists will meet again in spring 2013 at a Science Workshop in Fairbanks, AK. There are two primary objectives of the Science Workshop: 1) to facilitate communication between the science and management communities within the NWB region; and 2) for regional and subject-matter experts to discuss approaches for fulfilling the priority information needs that were generated in the Management Framing Workshop. The strategies resulting from these two workshops will serve as the foundation for the NWB LCC Strategic Science Plan.

Introduction to the Information Needs Matrix

Colleen Matt introduced the NWB LCC Matrix of Information Needs as an organizational tool for generating a list of information needs (App. A, Table 2). The components of the axes, Valued natural and cultural resources (y-axis) and Drivers of change (x-axis) were created from early information needs assessments held by NWB LCC in 2012. These initial assessments began with a questionnaire distributed by Steering Committee members within their own organizations in April 2012. In July 2012, the Steering Committee used the results of the questionnaire to identify priority and cultural resources.

The Management Framing Workshop participants received the draft matrix in advance of the workshop in order to allow them to receive feedback from within their respective organizations. The objective was to gain input from a wider selection of staff within each organization prior to attending the workshop. At the workshop, the participants began by evaluating the x- and y-components of the matrix. They broke into small groups and were asked to discuss the resources and drivers of change. After reconvening and further discussion by the entire group, the following changes were made to the initial matrix:

Changes to the Y-axis, “Valued natural and cultural resources”

- Grasslands added under the subheading Habitats
- Threatened and endangered species (Species of Concern) added under the subheading Species/Populations
- Minerals was added under the subheading Other
- The category, River/Stream/Lake, was separated into two aquatic categories, River (Lotic) and Lake (Lentic), under the subheading Habitats
- Glacial added under the subheading Habitats

Changes to the X-Axis, “Drivers of Change”

- The driver, Enduring Features, was added. Enduring features included bedrock, parent materials and topography
- Ocean Acidification was broadened to Marine Influence
- Introduced species was discussed but was considered subsumed by Invasive Species
- The driver, Land-Use Change, was discussed. Many participants thought the category was too broad to deal with the myriad effects of anthropogenic change. The group decided to add Pollutants and Contaminants as driver of change, and Consumptive Uses of Natural Resources was added to account for impacts of human use of resources.

Amanda reminded the participants that the driver categories are interrelated and concurrent, and that the matrix is only meant to be a tool for generating the ultimate goal, a list of relevant information needs. Rather than looking at the drivers as separate forces, participants should also consider how drivers interact and intensify each other.
During this first step, members of the Steering Committee reaffirmed the NWB LCC’s principal of including Traditional Ecological Knowledge (TEK) as a critical source for information in all of the group’s efforts.

The revised Information Needs Matrix was emailed to all of the participants at the workshop so they could continue their work on their own laptop computers.

**Identifying the range of decisions and develop a list of key outcomes or objectives**

Prior to tackling the information needs, participants were asked to brainstorm the range of decisions made by the various land use managers within the NWB LCC region, and the outcomes of interest to the managers. They received several background materials to help them think about criteria for prioritizing information needs (App. B):

- NWB LCC Vision, Mission and Goals
- North Pacific LCC Preliminary List of Decision Types
- Western Alaska LCC’s types of decisions & broad outcomes of management interest
- North Pacific LCC Preliminary Set of Outcomes of Interest to End-Users
- North Pacific LCC Brainstormed List of Potential Information Needs
- Priorities from NWB LCC Partnership Community not represented on the Steering Committee

To organize their efforts and discussion, the participants used blank cells from the Information Needs Matrix. Each team of two or three participants was given a stack of blank cell worksheets (App. B), and for each cell they ascribed a **driver of change** and a **valued natural or cultural resources** that was relevant to their organization’s range of decisions. After working in teams, the plenary group discussed their decision ranges in more detail. The blank cells helped workshop participants develop the Range of Decisions list (App. A, Table 3) and the Outcomes of Interest (App. A, Table 4) for the NWB LCC.

Holly Goulding of the Northern Climate ExChange delivered a presentation about the exchange’s work. Northern Climate ExChange is a program of the Yukon Research Centre, Yukon College.

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**Day 2 – October 31**

**Development of Information Needs**

The facilitators reviewed the previous day’s accomplishments and set the agenda for the day. The objective for the day was an unprioritized list of information needs for the LCC.

The participants in each of the Whitehorse, Fairbanks and Anchorage sites split into groups of 2-4 for the initial brainstorming session. Using the Information Needs Matrix, participants were tasked with developing a list of information needs relevant to the partner organizations of the LCC. For this first stage, each information need was developed in relationship to the two axes of the Information Needs Matrix.

After an hour of brainstorming, all of the groups’ lists were compiled and redistributed under the headings for each Driver of Change. The participants were then regrouped, and each group was given three or four lists. They were asked to cull the lists into 5-10 highest priority information needs for each driver. During this exercise, participants were reminded to keep a very broad perspective (i.e., at the “35,000 foot level”).
After completing the first “lumping, splitting and culling” task, the entire group looked at the compiled information needs under the Insect Disturbance driver category. As a plenary group, the participants suggested changes and modifications to make each information need discrete in scope, yet comparable in format. The plenary group reviewed two more driver categories, before breaking into smaller groups to perform the same process on the remainder of the driver category lists.

After the mid-afternoon break, the workshop facilitators projected the compiled driver categories one last time for review by the plenary group. Some information needs were lumped, others reworded, resulting in a list of 90 information needs (Appendix C).

Before the group adjourned, Jennifer Barnes, Regional Fire Ecologist from the Alaska Wildland Fire Coordinating Group and the National Park Service, presented “The Fire Research, Application and Development Committee.”

Yukon College hosted dinner for all of the participants, after which Yukon College engineering lecturer, John Streiker, presented his comments, “Climate change and its impact on the boreal region.”

**Day 3 – November 1**

**Information Needs Criteria Development**

On the first day of the workshop, the participants discussed their knowledge of two areas of common experience are that important for developing criteria: 1) the types of decisions that the LCC end users make, and 2) the set of outcomes that are of interest to end users. On the second day of the workshop, participants developed the “universe” of information needs that the LCC needs to prioritize. During the last day of the workshop, the participants were asked to develop weighted criteria with which to evaluate the information needs.

Criteria were defined as standards of judgment. The criteria developed during this workshop will be used later to evaluate and prioritize the information needs. The set of criteria should not be written in hierarchical order, though the participants may want to assign a higher range of values to denote the relative importance of one criterion over another. Development of the ranking criteria should take into account all of the information needs developed by the participants.

Ultimately, the criteria should support the mission and goals for the NWB LCC, and participants were asked to reread the mission and goals (App. B). In addition, the participants were given the following example criteria as a starting point for discussion.

- A. Breadth or range of decisions the information could support
- B. Potential information value
- C. NWB LCC Goals and Objectives (how well meets)
- D. Urgency of information needs
  1. Criticality of LCC-level participation (e.g., topic is not currently being addressed by anyone else)
  2. Opportunity for information collection exists now that may not exist in the future

The participants were reminded that this first set of evaluation criteria are meant to prioritize information needs and will not be used to prioritize research project proposals. Information needs are general statements about areas of uncertainty or risk for which additional data or research would be helpful to decision-makers. Projects are the specific actions needed to gather and/or analyze such data. The criteria for prioritizing information needs might be considered a “coarse
filter,” while the project selection criteria will be more of a “fine filter.” The development of project proposal selection criteria will be initiated at the spring LCC Science meeting.

The following discussions occurred as participants evaluated and modified the draft criteria:

**Criterion A -- Breadth or range of decisions the information could support, i.e., is the information critical to multiple organizations and/or LCCs?**

*Discussion Notes:*

This criterion restates the third bullet under the NWB LCC Goals, “Identifying and supporting scientific research, data collection, analysis, and sharing to address common information needs of land and resource management decision makers.”

On the first day of the Framing Workshop, the participants discussed both the *types of decisions that the end users make* and the *outcomes of interest to end users*. Both of these discussions were important to developing Criterion A.

The group debated whether it would be appropriate to add “the degree to which an information need is practical or feasible” to this criterion. However, they decided that the feasibility criteria would be more appropriate for project selection, and that the information needs criteria should be general enough to allow keystone information needs to rise to the top of the priority list.

**Criterion B -- Potential information value: 1) Degree to which information addresses key uncertainties; and 2) Information need is a prerequisite to investigating other information needs**

*Discussion Notes:*

Participants discussed, added and rejected several rewordings of this criterion, eventually ending up the final wording as above. One participant wanted to clarify that “potential information value” means “the degree to which information addresses key uncertainties.” As participants continued to define potential information value, they added, “Information need is a prerequisite to investigating other information needs.” Because the definition of information value included these two parts, it was split into two criteria under one heading.

The group discussed the necessity of adding another criterion, “the reliability or accuracy of information.” However, they decided that such a criterion would not apply for prioritizing information needs. It was decided that reliability and accuracy are important outcomes and should be built into the data standards for the LCC as well as the project selection criteria. Group members want to be as certain as possible that project outputs address the information needs.

There was some discussion about whether this criterion should be focused more narrowly on management uncertainties, or on ecological context and the need to understand the basic ecosystem function and processes. There was some disagreement within the group on this issue. However, it was decided to leave the criterion with broader language so that both viewpoints could be accommodated.

A participant asked whether it is important to devise a criterion that addresses the timeliness of management needs, i.e., now or in the future. The LCC coordinators responded that this is an important issue for the LCC, and it is in everyone’s interest to do both. The LCC should consider projects with long-term benefits that will deliver information over time, and it should also consider short-term projects that will have immediate pay-off. The discussion ended with an open
question about the value of applying a criterion that supported short-term need fulfillment or long-term gains, and how such a criterion could be applied. The group agreed that the idea should be revisited during the development of criteria for assessing project proposals.

Another participant asked whether a criterion about spatial breadth was warranted, i.e., should information needs necessarily receive higher priority if they serve the entire LCC, and presumably, more of the partner organizations’ needs. Another participant expressed the need for scalable land cover maps, i.e., locally-collected information should be able to be integrated into larger scale maps. It was noted that this concern is covered in the NWB LCC Goals, and that Criterion C refers to the goals. The LCC Coordinators also noted that these spatial concerns and the scalability of mapped information should be considered during the development of the project proposal criteria.

Criterion C -- Degree to which fulfilling the information need advances the NWB LCC Goals and Objectives

Discussion Notes

The group discussed the possible rewording of this criterion to read, “is consistent with the NWB LCC Goals and Objectives.” However, another participant said that the original wording, “NWB LCC Goals and Objectives (how well meets),” seems more like a filter than a criterion, and as such, it should be a pass/fail test, and not a ranked criterion. The group reworded the criterion to solve this problem, settling on “Degree to which fulfilling the information need advances the NWB LCC Goals and Objectives.” The Steering Committee should have the goals and objectives listed for their reference when they are applying this criterion.

Criterion D -- The information need would not be fulfilled without the support of a broad partnership: 1) Information need is not being addressed by anyone else and 2) Information need has the potential for leveraging resources to fulfill information need

Discussion Notes:

Looking at the original wording of this criterion, a participant pointed out that the term “urgency” can be interpreted in at least two different ways. For example, is the need not being currently addressed and should be? Alternatively, is this information need of a nature that no individual partner is responsible for it but has relevance to the whole LCC? The group agreed to define the criterion more specifically. The first part will read, “The information need would not be fulfilled without the support of a broad partnership.” In other words, the topic is not being addressed by anyone else. The second part will read, “Potential for leveraging resources to fulfill information needed.”

As a test case, a participant imagined a scenario in which an information need is not being addressed by a specific responsible agency despite its' relative urgency. Theoretically, the LCC could address such a need, assuming that the agency alone could not address the need. Alternatively, the responsible agency could address the need and chooses not to address it, despite the high priority of the need for the membership of the LCC.

Someone asked if this criterion adequately addressed the concept of data gaps. Others responded that all of the information needs are data gaps. The criterion is merely a tool for ranking the information needs and data gaps.
Another participant expressed the concern that there may be very valuable ongoing projects that could use LCC support. It would be too bad if this criterion restricted the LCC from participating with other LCCs on priorities or projects.

Another participant questioned whether the criteria as written will elevate only the information needs that are inherently collaborative. Others responded, saying that even if an information need is only one partner agency’s responsibility, fulfilling that need should benefit the whole LCC.

*REMOVED: Criterion E -- Opportunity for information collection exists now but may not exist in the future*

*Discussion Notes:*
The group debated this criterion, finally agreeing that Criterion D addressed the “urgency” issue. Criterion E would be better as part of the project selection criteria since it is not be possible to know the urgency of the specific projects until we are assessing them at the project proposal level. After removing Criterion E, there were four main criteria, with Criteria B and D bisected, for a total of 6 criteria (App. A, Tables 5 and 6).

*General discussion about information needs criteria*
Prioritized information needs will help the NWB LCC Steering Committee develop a Strategic Science Plan to guide how it disburses project funding over the next two to five years. The Steering Committee will also need to decide how many years the science plan will be valid before it is revised. Hopefully, the Steering Committee will have a better idea of their budget when they meet next February. The prioritized list of information needs will provide guidance for the next fiscal year, until the full science plan is completed.

After some discussion, the group decided that it would be best to rank information needs that are comparable in scope, time, and feasibility. For example, some participants were concerned that immediate management needs might not compete well compared to global information needs such as LCC-wide vegetation maps. The Steering Committee leadership accepted the task of “binning” the information needs into categories with commonalities. The weighted criteria would be applied to information within these categories.

*Assigning value to the Criteria through weighting*
Ranking is a subjective and value-laden process at its core. While this approach helps scientists document an amount of consistency into that subjective process, the end result is still subjective as opposed to a purely objective approach.

The group discussed the pros and cons of assigning different value ranges for each criterion. For example, Criterion A could have a range of 0-5 points, and Criterion C could have a range of 0-20 points. This would allow Criterion C to receive more points and a higher score. Alternatively, each criterion could be assigned a “multiplier” weighting, for example, 1.5 times for every rank. Another participant warned that if they used a very small range like 1 to 3, they might end up with a lot of tied rankings.

The group decided to use a range of values from 1 to 5 for each of the six criteria. It will be important to look both across and down the spreadsheet to rank the needs in relation to other needs, i.e., to rank them relative to each other.

To try out the newly weighted criteria, the group rated two examples, 1) Current scalable land cover data; and 2) Identification of at-risk aquatic habitats due to mining sites (App. A, Table 6).
In the process of ranking the examples, the group recommitted to dividing the information into categories of “like” needs so that information needs with commonalities are compared to one and other.

Subcommittees and next steps

The LCC leaders discussed how to proceed after this Framing Workshop. The following steps were discussed and a task list with responsibilities and deadlines were developed.

Next Steps:

- Determine the date and venue for the February Steering Committee meeting in Anchorage
- Determine the date and venue for the Science Planning Workshop in April or May in Fairbanks
- Initiate LCC Webinar Series
- Apply information needs criteria to the list of information needs
  - Finalize draft rewording of information needs
  - Develop “bins” for similar information needs
  - Develop background information to accompany information needs if needed
  - Develop and distribute draft workshop summary and sorted list of information needs to participants
  - Collect comments and edits on draft workshop summary and information needs; incorporate edits
  - Steering Committee will rank the final draft list of the information needs
- Steering committee will decide how to apply FY 13 project funding
Appendix A: Tables and figures

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Table 1. NWB LCC Framing Workshop participants

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
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<tbody>
<tr>
<td>Valerie Barber</td>
<td>UAF Cooperative Extension</td>
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<tr>
<td>Jennifer Barnes</td>
<td>National Park Service/Alaska Wildland Fire Coordinating Group</td>
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<td>Randy Brown</td>
<td>US Fish and Wildlife Service</td>
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<td>Phil Burton</td>
<td>Canadian Forest Service</td>
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<td>Glenn Chen</td>
<td>Bureau of Indian Affairs</td>
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<td>Hilary Cooke</td>
<td>Wildlife Conservation Society of Canada</td>
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<td>John DeLapp</td>
<td>Northwest Boreal LCC</td>
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<td>Maureen deZeeuw</td>
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<td>Steve Hartmann</td>
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<td>Chris Hawkins</td>
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<td>Jamie Kenyon</td>
<td>Ducks Unlimited Canada</td>
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<td>Gary Larsen</td>
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<tr>
<td>John Lingaas</td>
<td>National Oceanic and Atmospheric Administration, National Weather Service</td>
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<td>Jeremy Littell</td>
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<td>Maggie MacCluskie</td>
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<td>Carl Markon</td>
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<td>Colleen Matt</td>
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<td>Nathan Millar</td>
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<td>Brian Sieben</td>
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<td>Ryan Toohey</td>
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<td>Nicole Troyer</td>
<td>US Airforce</td>
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<td>Chris Tunnock</td>
<td>British Columbia Ministry Forests, Lands, and Natural Resource Operations</td>
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<td>Valued natural and cultural resources</td>
<td>Drivers of Change</td>
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<td>Wildfire</td>
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<td>Wetlands</td>
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<td>Riparian</td>
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<td>Lake (Lentic)</td>
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<td>River (Lotic)</td>
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<td>Marine/Nearshore</td>
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<td>Glacial</td>
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<td>Grassland</td>
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<td>Species/Populations</td>
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<td>Mammals (non-game)</td>
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<td>Mammals (game)</td>
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<td>Migratory birds (non-H2O)</td>
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<td>Resident birds</td>
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<td>Waterfowl</td>
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<td>Anadromous fish</td>
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<td>Resident Fish</td>
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<td>Insects</td>
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<td>Forest trees</td>
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<td>Understory plants</td>
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<td>Lichen/mosses</td>
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<td>Species of Concern</td>
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<td>Other</td>
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<td>Biological communities</td>
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<td>Food webs/Productivity</td>
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<td>Landscape connectivity</td>
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<td>Permafrost</td>
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<td>Soils</td>
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<td>Carbon storage</td>
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<td>Subsistence resources</td>
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<td>Public health</td>
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<td>Community Infrastructure</td>
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<td>Cultural Sites</td>
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<td>Forest products</td>
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<td>Resilience</td>
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<td>Oil/Gas/Coal</td>
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<td>Mineral</td>
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<td>Wilderness</td>
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<td>Water (Ground &amp; Surface)</td>
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Table 3. Range of decisions made by the NWB LCC partner organizations

<table>
<thead>
<tr>
<th>Decision Area</th>
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<tbody>
<tr>
<td>Oversight of industrial developments regarding natural resource impacts</td>
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<tr>
<td>Management and suppression of wildfire</td>
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<td>Management of invasive species</td>
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<td>Identification and prioritization of conservation areas (e.g., ACECS, RNAs,</td>
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<td>wildlife migration corridors)</td>
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<td>Land use planning (e.g. allowable uses, management of activities)</td>
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<td>Land use regulations</td>
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<td>Land use management</td>
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<td>Management of habitat and species</td>
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<td>Allocation for funding and personnel</td>
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<td>Best practices for protected areas</td>
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<td>Mitigation and restoration of habitat</td>
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<tr>
<td>Education and outreach regarding natural resources</td>
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<td>Conservation and management of cultural resources</td>
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<tr>
<td>Management of permafrost dynamics through allocation and zoning</td>
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<td>Protection of stream hydrology</td>
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<td>Permitting of road right of ways near conservation units</td>
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<td>Harvest parameters for fish and wildlife</td>
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<td>Fish and wildlife population monitoring</td>
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<td>Forest management</td>
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Table 4: Outcomes and objectives of interest to the NWB LCC partner organizations

- Improve ecosystem health and diversity
- Minimize impacts to caribou habitat, especially lichen forage
- Maintain and improve subsistence resources
- Reduce introduction and spread of invasive species
- Reduce habitat fragmentation
- Maximize efficiency and quality of planning and decisions
- Maximize economic benefits of natural resources, including fish and wildlife
- Minimize impacts to species of concern
- Maintain ecological function to benefit waterfowl populations
- Maximize military and recreational use while sustaining the environment
- Minimize negative impacts to natural, cultural, and subsistence resources
- Maximize conservation and harvest of fish and wildlife in the face of climate change
- Maintain or improve connectivity between established conservation units
- Minimize negative impacts to aquatic organisms including fish
- Minimize wildlife migration obstructions (birds, aquatic and terrestrial wildlife)
- Sustain availability of groundwater for both human and natural resource use
- Maintain the quality and quantity of water supply
- Maintain or improve public health and safety
- Maintain or improve carbon sequestration
- Maximize the economic benefits of forest products
- Maintain or increase fish and wildlife populations
- Sustain natural resource productivity and reduce contaminants
- Provide timely notice of hydrologic extremes, particularly flooding to prevent habitat destruction or property damage
- Allow for natural wildfire processes that minimize infrastructure or cultural resource loss
- Management of permafrost
- Minimize impact on community infrastructure
Table 5. List of information needs prioritization criteria, without weighting

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Breadth or range of decisions the information could support, i.e., is the information critical to multiple organizations and/or LCCs?</td>
</tr>
<tr>
<td>B.</td>
<td>Potential information value</td>
</tr>
<tr>
<td></td>
<td>1. Degree to which information addresses key uncertainties</td>
</tr>
<tr>
<td></td>
<td>2. Information need is a prerequisite to investigating other information needs</td>
</tr>
<tr>
<td>C.</td>
<td>Degree to which fulfilling the information need advances the NWB LCC Goals and Objectives</td>
</tr>
<tr>
<td>D.</td>
<td>The information need would not be fulfilled without the support of a broad partnership</td>
</tr>
<tr>
<td></td>
<td>1. Information need is not being addressed by anyone else</td>
</tr>
<tr>
<td></td>
<td>2. Potential for leveraging resources to fulfill information need</td>
</tr>
</tbody>
</table>
Table 6. Weighted Criteria for Evaluating Information Needs. Workshop participants practiced applying the criteria on two examples of preliminary information needs.

<table>
<thead>
<tr>
<th>Range of Values</th>
<th>A. Breadth or range of decisions the information could support, i.e., is the information critical to multiple organizations and/or LCCs?</th>
<th>B. Potential information value</th>
<th>C. Degree to which fulfilling the information need advances the NWB LCC Goals and Objectives</th>
<th>D. The information need would not be fulfilled without the support of a broad partnership</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Info Need Ex. Current (scalable) land cover geospatial data</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Info Need Ex. Identification of at risk aquatic habitats LCC-wide due to mining sites</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
Appendix B: Workshop Handouts
Northwest Boreal Forest LCC

MANAGEMENT FRAMING WORKSHOP
October 30 – November 1, 2012
President’s Board Room, Yukon College, Whitehorse, YT

Contents:
- NWB LCC Vision, Mission and Goals
- North Pacific LCC Preliminary List of Decision Types
- Western Alaska LCC’s types of decisions & broad outcomes of management interest
- North Pacific LCC Preliminary Set of Outcomes of Interest to End-Users
- North Pacific LCC Brainstormed List of Potential Information Needs
- Priorities from NWB LCC Partnership Community not represented on the Steering Committee
- Blank Information Needs Matrix Cell
Vision and Mission Statements:

Vision: A landscape that sustains functioning, resilient boreal ecosystems and associated cultural resources in perpetuity.

Mission: To promote coordination, development, and dissemination of applied science to inform landscape level conservation in the face of a changing climate and other stressors.

NWB LCC Goals:
The overarching goal is to inform conservation and sustainable resources management within the NWB LCC by:

- Providing better understanding and prediction of effects of climate change and other stressors on landscape level physical and ecosystem processes;

- Supporting coordination, collaboration and communication among partners to facilitate knowledge exchange and improve efficiencies in their individual and shared science and information activities;

- Identifying and supporting scientific research, data collection, analysis, and sharing to address common information needs of land and resource management decision makers;

- Providing landscape scale information to better understand and plan for potential impacts of environmental change on natural resources, subsistence and cultural resources, and human infrastructure;

- Supporting and coordinating the collection and synthesis of baseline information and monitoring, and enabling data management and information synthesis at landscape scales; and by

- Engaging the community at large to help identify shared science needs, collaborate and leverage opportunities to address shared science needs, and avoid duplication of efforts.
Handout: North Pacific LCC Preliminary List of Decision Types

Table 1 contains some of the types of decisions and examples of relevant decision makers responsible for those decisions. The table is not meant to be complete either in terms of capturing all of the detailed decisions or the relevant decision-makers for each; rather it illustrates the variety of decisions and the commonality of types across multiple agencies and organizations. Decisions shared by many organizations become relevant when discussing common information needs.

Table 1. Types and examples of decisions related to natural, cultural, and water resource management in the NPLCC region, examples of (some of) the relevant decision-makers and stakeholders for each

<table>
<thead>
<tr>
<th>Decision types, example decisions</th>
<th>Examples of relevant decision-makers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Decisions about conservation models employed</strong></td>
<td>Many</td>
</tr>
<tr>
<td>Mitigation and restoration decisions (where, how, when)</td>
<td>Federal, state, and provincial agencies (e.g., Restoration coordinators, Environmental assessment decision-makers, permitting entities), Aboriginal decision-makers, Tribal Councils</td>
</tr>
<tr>
<td>- Restoration of ecological function of shorelines</td>
<td></td>
</tr>
<tr>
<td>- Prioritizing areas for conservation and mitigation</td>
<td></td>
</tr>
<tr>
<td>- Restoration contract specifications</td>
<td></td>
</tr>
<tr>
<td>Identification and prioritization of areas/species for conservation</td>
<td>Federal, state, and provincial agencies (e.g., BLM managers, Provincial Cabinet Subcommittee, State Fish and Game planners), Joint Ventures, NGOs</td>
</tr>
<tr>
<td>- Identifying high priority areas for conservation</td>
<td></td>
</tr>
<tr>
<td>- Prioritizing species and habitats for conservation and management</td>
<td></td>
</tr>
<tr>
<td>- Decisions to defend, mitigate, move, abandon a place;</td>
<td></td>
</tr>
<tr>
<td>Decisions about mitigating and compensating for land/habitat/species loss in specific geographic areas</td>
<td>Federal, state, and provincial agencies (e.g., policy level decision-makers)</td>
</tr>
<tr>
<td>Land use decisions / decisions about allowable activities</td>
<td>Numerous, including: Federal, state, and provincial agencies (e.g., Environmental assessment decision-makers, Provincial Cabinet Subcommittee, State Fish and Game planners), Aboriginal decision-makers, Tribal Councils, Joint Ventures, NGOs</td>
</tr>
<tr>
<td>- Land use designation (areas of critical environmental concern)</td>
<td></td>
</tr>
<tr>
<td>- Location &amp; establishment of parks, conservancies, other areas for protection</td>
<td></td>
</tr>
<tr>
<td>- Constraints on planned uses or activities</td>
<td></td>
</tr>
<tr>
<td>- Zoning, etc. – affecting where and how growth happens</td>
<td></td>
</tr>
<tr>
<td>- Permitting of various activities on the landscape</td>
<td></td>
</tr>
<tr>
<td>- Wetland easement terms (and terms of any easement?)</td>
<td></td>
</tr>
<tr>
<td>Decision types, example decisions</td>
<td>Examples of relevant decision-makers</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------------------------------</td>
</tr>
</tbody>
</table>
| **Land management decisions / decisions about managing allowable activities**  
- Forest land management plans  
- Development, transportation, land planning  
- Infrastructure development and maintenance (roads, pipelines, transmission lines, etc.)  
- Invasive species prevention, management, and designation  
- Fire management strategies  
- Drought management strategies  
- Agricultural practices  
- Aquaculture practices  
- Energy (renewable energy) development | Land owners and land managers at all levels, including private land owners |
| **Water allocation, use and management**  
- Hydropower & reservoir management  
- Irrigation methods | Water managers (at all levels) |
| **Species management decisions**  
- Harvest levels  
- Management of an isolated species  
- Maintenance and restoration of fish passages  
- Translocations  
- Disease control (plants, wildlife, livestock) | Wildlife and Fisheries managers, Park superintendents, Refuge managers, regulatory agencies (at all levels) |
| **Decisions about cultural and historic resources**  
- Preservation of cultural and historic resources (where, how, when)  
- Relocation of tribes and tribal (trust) lands and cultural and heritage sites (including migration of trust species)  
- Decisions about mitigating and compensating for losses | Federal, state, and provincial agencies, Tribes (e.g., Historic preservation officers) |
| **Where and how to monitor for environmental changes** | Many |
| **Decisions about education/outreach (where, when, and how)**  
- How to communicate information about stressors and changes (how to tell the story) | Everyone |
| **Private investment and development decisions**  
- Capital investments  
- Locations of facilities  
- Provision of insurance | Various private industries (e.g., wood products mill owner, cannery, utilities, renewable energy developers) |
| **Decisions about how to use natural resources**  
- Participation in sporting & recreational activities  
- Collection of materials necessary for individual use (e.g., where to collect basket making materials) | Individuals |
<p>| <strong>Decisions about standing, tribal sovereignty</strong> | Tribes, federal agencies |</p>
<table>
<thead>
<tr>
<th>Decision types, example decisions</th>
<th>Examples of relevant decision-makers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulations &amp; legislation</strong></td>
<td>Congress, federal agencies (e.g., EPA – Office of Water), regulators at all levels</td>
</tr>
<tr>
<td>- Industry regulations and oversight</td>
<td></td>
</tr>
<tr>
<td>- Decisions about quality standards</td>
<td></td>
</tr>
<tr>
<td>- Establishing enforceable targets for water pollution reductions</td>
<td></td>
</tr>
<tr>
<td>- Design of incentives, market based trading schemes, protocols and procedures for ecosystem services / emerging markets</td>
<td></td>
</tr>
<tr>
<td>- Decisions about government structure, how you govern, staffing, etc.</td>
<td></td>
</tr>
<tr>
<td><strong>Decisions about control of and response to infectious (human) diseases</strong></td>
<td>Federal, state, and provincial agencies (e.g., CDC), municipalities (e.g., local health entities)</td>
</tr>
<tr>
<td><strong>Decisions about climate change prevention</strong></td>
<td>Many</td>
</tr>
<tr>
<td><strong>Allocation of agency or entity resources (funding, personnel) among various research efforts and conservation efforts.</strong></td>
<td>Federal, state, and provincial agencies, municipalities and local communities, Tribes, NGOs, etc.</td>
</tr>
<tr>
<td><strong>Decisions about information and knowledge governance</strong></td>
<td>Many agencies</td>
</tr>
<tr>
<td>- Monitoring and data collection decisions</td>
<td></td>
</tr>
<tr>
<td>- Consistent data sets</td>
<td></td>
</tr>
<tr>
<td>Note: the NPLCC itself may choose to take on a role and be a decision-maker for some of these decisions</td>
<td></td>
</tr>
</tbody>
</table>
Handout: Western Alaska LCC’s types of decisions & broad outcomes of management interest

Table 2.2. Seven types of decisions commonly made by WALCC partner agencies

- Decisions about land and water use
- Decisions directly affecting habitat
- Decisions directly affecting species
- Decisions about setting quality standards
- Decisions about industry oversight
- Decisions about infrastructure and community development
- Decisions about cultural resources

Table 2.3. Eight broad outcomes of management interest common to WALCC partner agencies

- Ecosystem function
- Habitat quality
- Population health (for individual species)
- Public health and safety
- Economic benefits
- Protection of culture
- Community stability
- Quality of outdoor experience

Both tables copied from:
Handout: North Pacific LCC Preliminary Set of Outcomes of Interest to End-Users

The list below shows the preliminary set of outcomes of interest or objectives of conservation-management decisions identified by the workshop participants. This list is organized by higher-level objectives, with some potential sub-objectives listed under each major category of outcome.

This list also does not consider (yet) the inevitable trade-offs that must be made between these objectives, and no priority is implied by the list order. It is important to note again that these are not the objectives of the LCC itself, but rather the objectives of the end-users that the LCC aims to support.

Maximize habitat quality and species population health
• Quantity and quality of habitat for species of management interest, including but not limited to:
  o Habitat permanently conserved for birds during all life cycles
  o Oceans
  o Old growth forests
  o Designated wetlands
  o Habitat for rare and endemic species
• Quality of near-shore function/habitat/resilience to sea level rise
• Risk of harm to species, species extinctions
• Health of federal species at risk and allow to thrive without intervention
• Number of depleted fish populations, Productivity of fisheries
• Species biodiversity (in situ)

Maximize ecosystem function and services
• Health of ecosystems
• Ecological function and sustainability of working lands (farms, forests, etc.)
• Accounting systems’ ability to capture value of ecosystem function
• Forest ecosystem ability to adapt to climate change
  o Ecosystem function
  o Water availability
  o Susceptibility to fire
  o Quantity of renewable resources
• Carbon sequestration capacity of ecosystems

Maximize cultural resources
• Abundance, access and quality of cultural resources
• Continue and restore tribal life ways including cultural and subsistence resources
• Use of traditional cultural practices

Maximize ability of tribes to exercise treaty rights
• No diminishment of treaty hunting or fishing rights

Maximize economic benefits
• Economic opportunities, now and in future
• Jobs, career opportunities, technology development
• Economic security of native villages and rural communities associated with National Forest land
• Economic stability
• Loss of infrastructure investments due to sea level rise
Maximize education
- Education of landowners, public
  - Public engagement in park-based education related to climate change
- Number of elementary and secondary courses promoting wise use of resources
- Awareness by public and elected officials of scope and magnitude of current and probable future climate change impacts
  - Create public expectation of accurate up-to-date information on climate change and that large scale landscape conservation is in the public interest (including individual and collective financial interests)

Maximize water quality and availability
- Resource (water) efficiency of agriculture
- Sustainability of groundwater use
- Flow of ecological water and in the right places
- Use of pesticides
- Flow of contaminants into surface water and groundwater

Minimize GHG emissions and CO2 concentration in atmosphere

Maximize security and human health
- Frequency and severity of diseases
- Food production
- Ability to respond to natural disasters
- Coordination with international security agencies

Note: The following three categories of objectives represent outcomes that may be relevant not only for the natural, cultural, and water resource managers but also for the NPLCC itself.

Maximize quality of decision making
- Efficiency of decision making
- Identification of policy and legislative impediments to good decision making
- Scientific and management efficacy of an all-lands approach
- Quality of cross-jurisdictional decision making, including land-sea
- Cross-stakeholder data sharing
- Buy-in to long-term monitoring
- Use of best climate change information in decision making

Maximize diversity of groups involved with coordinated climate change decision making

Maximize global recognition of excellence in sustainable resource management and economic development
Handout: North Pacific LCC Brainstormed List of Potential Information Needs

Workshop participants developed a list of potential information needs, with the decision and outcome links identified, as summarized in Table 2. This list was developed as a starting point and to illustrate another approach for identifying information needs; it is not intended to be comprehensive.

The list below is sorted by relevant decision. Even though the list is not yet complete, it is also useful to sort also by outcomes of interest. Table 3 contains the same list, but is sorted by outcome of interest, which helps to identify more directly what information would be needed to predict a specific outcome. The intent of creating these tables and developing initial conceptual models is to begin the identification of information needs for decision makers in the NPLCC.

Table 2. Examples of potential information needs identified during workshop discussions, sorted by relevant decision

<table>
<thead>
<tr>
<th>Relevant decision(s)</th>
<th>Uncertainty (Information/Science Need)</th>
<th>Outcome(s) of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Priorities for information collection</td>
<td>• Inventory of existing information (semantics, ontology, interoperability)</td>
<td>• All</td>
</tr>
<tr>
<td>• Priorities for information collection</td>
<td>• Framework to identify what is currently known and not known</td>
<td>• All</td>
</tr>
<tr>
<td>• Information sharing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Land management</td>
<td>• Methods for prioritizing and making tradeoffs</td>
<td>• Maximize habitat quality and species population health</td>
</tr>
<tr>
<td>• Species management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Education and outreach</td>
<td>• Current public perceptions; effectiveness of different communication strategies</td>
<td>• Maximize public awareness and education</td>
</tr>
<tr>
<td>• Restoration and mitigation decisions</td>
<td>• Effect of changes in ocean and near-shore water conditions (e.g., temperature, currents, level on the lifecycle of fish and other animal species)</td>
<td>• Maximize habitat quality and species population health</td>
</tr>
<tr>
<td>• Land management / forest management</td>
<td>• Effect of habitat fragmentation on species population health</td>
<td>• Maximize habitat quality and species population health</td>
</tr>
<tr>
<td>• Species management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Restoration and mitigation decisions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Zoning and land protection</td>
<td>• Vulnerability of the near-shore to sea level rise</td>
<td>• Maximize economic well-being</td>
</tr>
<tr>
<td>• Investments</td>
<td></td>
<td>• Maximize habitat quality</td>
</tr>
<tr>
<td>• Restoration activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Changes in land use</td>
<td>• Identification of at-risk habitats and the sources of risk to those habitats</td>
<td>• Maximize habitat quality and species population health</td>
</tr>
<tr>
<td>• Mitigation and restoration</td>
<td>• Ocean acidification: extent, timing, effects, and the availability and effectiveness of mitigations</td>
<td>• Maximize habitat quality and species population health</td>
</tr>
<tr>
<td>• Mitigation and restoration decisions</td>
<td>• Relative risk from different stressors; ability to compare stressors and their effects over time</td>
<td>• Maximize economic benefits</td>
</tr>
<tr>
<td>• Priority setting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Internal resource allocation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Species management</td>
<td>• What is causing decline in [various migratory bird] species?</td>
<td>• Maximize habitat quality and species population health</td>
</tr>
<tr>
<td>• Species management (e.g., fish passage)</td>
<td>• Hydrological information, especially at elevation; snow/rain phase, bed load stability, channel stability</td>
<td>• Maximize habitat quality and species population health</td>
</tr>
<tr>
<td>• Water allocation, use, and management</td>
<td>• Understanding of how partner organizations set priorities and make funding decisions</td>
<td></td>
</tr>
<tr>
<td>Relevant decision(s)</td>
<td>Uncertainty (Information/Science Need)</td>
<td>Outcome(s) of interest</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td></td>
<td>• Appropriate / most useful spatial and temporal resolution for multi-agency issues</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Maintenance of TEK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Relationships between restoration activities at various scales (and related joint information development)</td>
<td></td>
</tr>
<tr>
<td>Species management</td>
<td>• Species sensitivity to climate change</td>
<td>• Species population health</td>
</tr>
<tr>
<td>Mitigation</td>
<td>• Effects of hydrologic changes on fish population health (e.g. bioenergetics)</td>
<td>• Species population health</td>
</tr>
<tr>
<td>Fisheries management</td>
<td>• Shared data sets (e.g., rainfall intensity)</td>
<td>• Species population health</td>
</tr>
<tr>
<td>Land use/protection</td>
<td>• Ethical use of TEK, local knowledge, preserve and protect tribal ownership</td>
<td></td>
</tr>
<tr>
<td>Establishment of water pollution targets</td>
<td>• Incorporating soil properties into downscaled climate models, to more easily connect to biological models</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Understanding effects of “new normal” climate</td>
<td></td>
</tr>
<tr>
<td>Priority landscapes for habitat conservation</td>
<td>• Regional and LCC-wide trends in land use</td>
<td></td>
</tr>
<tr>
<td>Land management – many</td>
<td>• Inventory of existing conservation tools</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Effects of human activities on ecosystem health</td>
<td></td>
</tr>
</tbody>
</table>
Handout: Priorities from NWB LCC Partnership Community not represented on the Steering Committee

These priorities were taken from the vision and mission statements, and strategic plans posted on the websites of around 200 organizations within the NWB LCC geography; and supplemented by initial telephone conversations, meetings and e-mail responses. These priorities were incorporated in the INA activity and records from the July 31 SC meeting.

- Tourism/ wilderness dependent businesses/ ecotourism
- Land use/ Development
- Ecological restoration
- Responsible corporate growth
- Community plans/ sustainable communities
- Recreational opportunities
- Native languages/ cultures/ traditions
- Elements and conditions that contribute to the survival of Native cultures and societies, and identification of major barriers to cultural survival
- Utilization of traditional knowledge with consideration of intellectual property rights
- Food safety
- Vulnerability to storm surge and flooding
- Delayed winter shore ice
- Develop, conserve, enhance forests to provide a sustainable supply of forest resources
- Protecting water quality, fish and wildlife habitat, and other forest values through appropriate forest practices
- Development of the timber industry and forest products market
- Wildlife rehabilitation
- Potentially destructive development of Arctic waters and Arctic public land
- Aquatic ecosystem restoration
- Stormwater
- Shared heritage
- Rights/ tribal self-determination & self-governance
- Circumpolar biodiversity monitoring
- Emergency preparedness
- Environmental cleanup
- Navigational improvements
- Benefit and enjoyment of current and future generations
- Wildlife hotspots
- Commercial, sport and personal use fisheries
- Spill prevention and response
- Use of wood for value-added processing
- Forest legacy
- Transportation
- Regional land-use planning
- Enhance ecological resilience
- Education/ training
- Seismology
- Volcanology
- Biomedicine
- The character of the land
- Land and water stewardship
- Back hauling
- Brownfields
- Impervious surfaces
- Septic systems
- Continuance and enforcement of conservation laws
- Prepared for and Responds to Weather-Dependent Events
- Landscape Hazards: Geotechnical Mapping for Climate Change Planning - identifies landforms, sediments and landscape processes that may pose a threat to ongoing and future community-based development under current and changing climate conditions
- Arctic shipping safety
- Environmentally responsible hydrocarbon development and oil spill standards
- Anticipate climate change
- Timely, relevant, and impartial study
- Cold climate innovation
- Uranium Activity Rations as an indicator of melting permafrost
- structure
- Local food production
- Farming ecosystems
- Maintaining the health of the boreal forest
• Major controls over forest dynamics, biogeochemistry, and disturbance and their interactions in the face of a changing climate
• Gradual & abrupt change
• Emerging landscape patterns
• Identify buffers to radical changes in
• Adaptation tools
• Economic and social well-being
• Lake fertilization
• Clean boating and harbors
• Energy production and efficiency
• extend relevant research-based knowledge in an understandable and usable form; and to encourage the application of this knowledge to solve the problems and meet challenges
• NEPA permitting

• Long-term [forestry related] economic benefits for Northern communities
• Combining scientific knowledge, traditional knowledge and local perspectives to protect natural and cultural values
• Strengthen local economies
• Self-reliance
• Trail management
• Revitalize language and culture
• Climate change mitigation
• Climate-related risks and opportunities
Handout: Blank Information Needs Matrix Cell

Instructions: Refer to the NWB LCC Matrix. Use this worksheet to discuss and list decision types, outcomes of interest, and information needs for each cell.

A) List the types of decisions that you make or your organization makes. The list doesn't need to be exhaustive. Decisions shared by many organizations become relevant when discussing common information needs

B) What are some outcomes of interest or objectives of conservation-management? These are not the objectives of the LCC itself, but rather the objectives of the conservation managers that the LCC aims to support

C) List of potential information needs that would help you reach the outcomes of interest to you or your organization. The list doesn’t need to be comprehensive

<table>
<thead>
<tr>
<th>Resource of interest:</th>
<th>Driver of Change:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A) Decision Types:</td>
<td></td>
</tr>
<tr>
<td>B) Outcomes/Objectives of interest to management:</td>
<td></td>
</tr>
<tr>
<td>C) Information needs relative to above decision types and outcomes of interest:</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C: Information Needs Lists
Northwest Boreal Forest LCC

MANAGEMENT FRAMING WORKSHOP

October 30 – November 1, 2012

President’s Board Room, Yukon College, Whitehorse, YT

Contents:
1. Initial List of Information Needs generated at the Framing Workshop
2. Revised List of Information Needs as of 1/11/13
Initial List of Information Needs generated at the Framing Workshop

Using the Information Needs Matrix, participants were tasked with developing information needs relevant to the partner organizations of the LCC. After the initial brainstorming, the information needs were divided into lists under individual Driver of Change headings. These lists were redistributed and went through two stages of sorting, combining, and augmenting by subgroups of the workshop participants. The lists of information needs at the end of the day were still considered “raw.” On the third day of the workshop, the group decided that it would be best to rank information needs that are comparable in scope, time, and feasibility. After the workshop and before the ranking process, the Steering Committee agreed to group the information needs into categories with commonalities. The resulting regrouped list appears in this Appendix subsequent to the following Initial List.

Glacial melt/stream discharge

- documentation of
  - Seasonal minimum flow measurements
  - Rates of glacial surface change
  - Quantity and timing of surface flow relative to access
  - Information on timing of seasonal meltwater into the system
  - Stream discharge on riparian systems
- Hydrological basin Water Budget Model Decision Support Tool
- Effects on habitat, populations, and species diversity of
  - anadromous fish
  - resident fish
  - subsistence species
  - ungulate populations such as sheep and caribou that rely on these landscape features for insect relief
  - human use
  - Riparian wildlife

Growing Season Length Increase

- Monitor changes in species phenology (e.g., insect life stage development, plant flowering/fruiting, migration timing and prey availability)
- Map/monitor changes in plant and animal species distribution (e.g., treeline migration, shrubification of alpine tundra habitats)
  - Greening/ browning of LCC through satellite images.
- Evaluate effects of change in growing season on:
  - Distribution and abundance/productivity of species (including subsistence species/resources)
- Model future species distribution, abundance, and phenology based on future climate scenarios
- Link between growing season and fire season (esp. in shoulder seasons)

Insects

- Establish long-term insect impacts monitoring program across the region to determine the effects of pest insects on trees and traditional foods, focusing on the following:
  - Range expansion
  - Timing of outbreaks
  - Ability to penetrate new habitats
• Develop Predictive models linking climate change and land-use change with effects of pest insects, (e.g., spruce bark beetles, IPS, moose tick)
• Investigate the factors that limit pest insects in LCC? (e.g., low precip, thin cambium, other ecological restrictions)).
• Develop management strategies for alleviating tree stress
• Develop damage models for pest insect outbreaks, especially tree-killing species
• Baseline information on ecosystem function baseline info for insect/arthropod/macroinvertebrate: species abundance, diversity, habitats, relationship in food web (what do they feed on, who feeds on them?)
• Phenological changes – all insects

Invasive Species

Assessment
• Develop fine-resolution techniques to map the spread the spread of the two most highly invasive plant species (Elodea, Melilotus) in the most valuable and productive riparian and wetland habitats.
• Determine tolerances of invasive plants and insects based on climate comparisons (research which of the most highly invasive and dangerous ones from northern US and southern Canada might show up first in the NWIF LCC).
• What are the most probable vectors of invasive species introduction and spread and how can they be mitigated?

Monitoring
• Monitor spread of the most highly invasive plant species (merge AKEPIC GIS database with analogous Yukon/BC systems).
• Monitor distribution of the most highly invasive fish species (e.g. such as northern pike in south-central Alaska, rainbow trout in Yukon)
• Monitor/vigilance for spread of invasive mollusks and the potential of mollusk invasion via road systems and float aircraft.
• Determine effects of fire suppression operations on introduction and spread of invasive species.

Evaluation of impacts
(prioritize for the most highly invasive species e.g. white sweet clover, bird vetch, loosestrife, Elodea)

• Determine effects of invasive species on populations and species diversity of fish and wildlife
• Determine effects of invasive species on abundance and distribution of subsistence species/resources
• Determine effects of invasive species on ecosystem services
• Determine effects of bird vetch on understory plants as it invades
• Determine effects of invasive starlings on native passerines.
• Effects of climate change on the spread of invasives, insects, and pathogens? Alaska/Yukon-specific models of spread of invasive (based on climate comparisons of sources).
• How will anticipated climate change (drying, warming, etc) affect spread of invasive species?
• Perform vulnerability assessment to determine areas of highest risk of invasive spreads and highest risk of negative effects on important trust species (subsistence resources, salmon, migratory birds, moose, T&E species)... determine places where invasives are NOT known.
Public perceptions
- What are current public perceptions and effectiveness of different strategies regarding invasive species management?

Land-use change
Baseline data are required for many species, habitats, and systems in order to evaluate the effects of land-use changes.
- Life history:
  - Identification of critical aquatic habitats for anadromous and freshwater fishes, including migratory routes, spawning areas, and overwintering habitats.
  - Species habitat associations/suitability models
- Environmental monitoring/classification:
  - Landcover classification
  - Wetland inventory
  - Long-term stream flow and water quality monitoring program
  - Archeological surveys mapping
  - Permafrost decay with changing landcover/landuse

Baseline data are needed to quantify/characterize land-use change patterns across the LCC.
- Map the location of all existing anthropogenic disturbances:
  - Human Footprint Mapping (Roads/Trails/Land use conversion) e.g.:
    - Use of forest lands (e.g., recreation, timber extraction; etc.)
    - Gravel extraction, including reclamation efforts, BMP’s, etc.
    - Roads
  - Research Impacts of operational scale developments on wetland function
  - Data on the effects of increased road construction on use of lands by recreational (hunting and nonhunting) visitors, and the potential effects on regional fish and wildlife resources.
- Gather/collate existing management information/plans regarding restoration/BMP’s, etc.
- Monitoring program to assess changes in land use

Project future vulnerability to land-use change
- Identify regions of future vulnerability to land-use change disturbance:
  - Project access to lands for future land use (e.g., recreation, forest timber extraction, etc.) due to more snow-free days, melting permafrost
  - Impacts on cultural resources
  - Project future cumulative disturbances
- Relative Risks to Habitat from different stressors, ability to compare stressors and their effects over time.
- Effects of habitat fragmentation on subsistence and species of concern
- Identify locations at risk for future spread of invasive species (presence/absence)
Model the effects of the disturbances on ecosystems, habitat health, subsistence resources (vulnerability assessments):

- Identification of at risk species and habitats and the corresponding sources of risk (e.g., wetlands, alpine)
  - Including harvestable and subsistence species
- Methods for prioritizing and making tradeoffs in relation to management decisions
  - Involve Tribal entities and First Nations into decision making

Marine Influence

- What will the impacts of marine stressors (e.g., acidification, pollution, overharvest) be on marine nutrient transport to ecosystems within the LCC?
  - Survey, mapping and data development
    - Information on marine-derived nutrients or pollutants
    - Population information anadromous fish (subsistence)
  - Impact analysis & modeling
    - Information on impacts on health and populations
    - Effects on habitat, populations, and species diversity of anadromous fish
    - Effects on habitat, populations, and species diversity of resident fish

Other

- Land Cover/mapping/imaging needs
  - Forest Inventory data for all lands in NWIF region
    - combine Canada/US data sets
      - Hyperspectral imaging to distinguish black from white spruce
    - High-resolution imaging
      - use environmental gradients to strategically address where to focus image collection;
    - consistent hydrological dataset for all of NWIF
      - National hydrological dataset ends at AK/Canada border needed for studies on salmon, pollutant transport, spread of invasive plant seed
- Monitoring landscape change
  - Monitor and/or model riparian and floodplain loss/change over time
- Baseline information on ecosystem function
  - baseline info for insect/arthropod/macroinvertebrate: species abundance, diversity, habitats, relationship in food web (what do they feed on, who feeds on them?)
  - More info on role of lichen/moss in ecosystem functioning, population surveys, protection methods, etc.
- Information needed to directly guide management:
  - Establish appropriate size, desired species etc. of riparian/wetland/shoreline buffer areas.
  - Should wildlife corridors through developed areas be maintained, or should populations be separated?
  - Is it possible/feasible to offer carbon credits for boreal forests?
- Basic Information on poorly-known species
  - Cook Inlet Beluga Whale: info on primary prey, calving grounds, threats from noise/human caused stressors
  - Bats, for southcentral Alaska and Anchorage in particular: species occurrence/diversity, habitat, threats, etc.
o Other non-game non-avian species including wood frog, microtines, pika, hare/lynx, wolverine, and Dall’s sheep.
o Rusty Blackbird and Olive-sided flycatcher: preferred habitat, diet, susceptibility to change and human-caused disturbance, etc.

• Methods/technology
  Drones to collect aerial photography/video

• Human Dimensions
  o Village economics
  o Patterns of migration
  o Land use change
  o Trends in recreation, non-consumptive uses and expectations of natural assets

Pathogens

Wildlife
• Integrated parasite and pathogen monitoring program in subsistence/harvested species
• Models of parasite and pathogen life cycles linked to regional climate model projections to assess range of possible changes in prevalence and distribution
• Address gaps in research assessing parasite or disease infestation levels / intensities with host population health and dynamics

Fisheries
• Integrated parasite and pathogen (including *Icthyophonus* and Whirling disease) monitoring program in subsistence/harvested species
• Models of parasite and pathogen life cycles linked to regional climate model projections to assess range of possible changes in prevalence and distribution
• Address gaps in research assessing parasite or disease infestation levels / intensities with host population health and dynamics
• Forest Pathogens

Permafrost Dynamics

*Improved mapping modeling, and monitoring program throughout the region (Includes location, depth, freeze/thaw rates, met stations)*

Data required on the effects of expected changes
  o Hydrology-surface and subsurface
  o Wetlands
  o Lakes, rivers, streams (including connectivity)
  o Biochemistry
  o Land use management
  o Species habitat and populations
  o Water quality, quantity
  o terrestrial plants (forests)
  o human use; public safety/health

• Access to and integration of permafrost data with other base line data
• Integration to TEK into research and land use management
• Predictive models on
  o changes in hydrology and effects to wetlands and wetland obligate species. Wetland Extent/Type
o Wetland Extent/Type
o Changes from carbon storage to carbon source- project future changes based on climate predictive models

Pollution/Contaminants
- Establish long-term contaminant monitoring program, using standardized protocols, across the region and to set baseline values to monitor effects of pollution on:
  o harvested species
  o public health
  o Other species of conservation concern

Snow Ice Dynamics
*Improved snow monitoring program throughout the region (Snow monitoring includes phenology, depth, freeze/thaw events, rain on snow events)*
- Data required on the effects of expected changes in snow depth on the subnivian environment and its effects on species.
- Document the effects of rain/icing events on snow events on species/communities (e.g., ungulates, trees). How will the projected events affect long-term population trends?

Temperature-Precipitation Change
- Information on stream flow, stream temperature, and water quality, using standardized protocols, on sufficient number of river systems to document the impacts of changes in temperature and precipitation on flow, temperature and water quality across the region.
- An on-line physiological threshold database for species like the Resilience Alliance database that documents ecological transitions (http://www.resalliance.org/index.php/database), but focused on climatic limits to individual species.
- Information on how increased temperatures will affect vegetation, snow-rain events, insect hatches, parasite and pathogen range expansions, etc. and the cumulative effect of temperature change on ungulates.
- Information on how changes in temperature and precipitation regimes will affect vegetative productivity through drought stress due to longer growing seasons/less effective moisture
- A model of anticipated climates, paired with information on ecosystem features in comparable current bio/geo/climatic conditions to allow forecasting of habitat change. (Similar to one developed by Jack Williams at University of Wisconsin that will draw lines to where the closest climate analog to the future climate exists. (http://www.wicci.wisc.edu/climate-map.php).
- Geo-spatial information on current and projected Permafrost distribution.
- Effects on phenology

Trends in Consumptive Uses of Natural Resources
- Effects on populations and species diversity of harvested anadromous fish
- Effects on populations and species diversity of harvested resident fish
- Effects on abundance and distribution of subsistence species/resources
Vegetation Composition Change

- What is the current distribution, condition, and spatial extent of vegetative species/communities within the LCC?
- What are future projected changes in vegetative species/communities?
- What are the impacts of vegetative change on ecosystem process, communities and species?

Information need: Synthesize veg plot data from all agencies that manage land

- Data sharing policies/procedures
- Combine AK and Canadian data sources

Information need: Inventory/ mapping (current state/baseline data)

- Mapping
  - Improved DEMs
  - Increased weather station coverage to improve biome/climate associations (improve SNAP climate projections)
  - Accurate LCC-wide coverage specific functional vegetation types or species (e.g., shrubby alders, larch, willow)
  - Baseline info on alpine biodiversity to know what we're changing from
  - Ecological Land Classification and mapping
    - Wetlands
  - Research possible other species that may do well in changing climate
    - Linked to vegetation change?
    - From other locations moving into the LCC?
    - Winners vs. losers of current inhabitants?

Information need: Monitoring change in vegetation composition, phenology, and productivity and carbon sequestration

- Permanent sample plots to monitor vegetative communities composition/change (e.g., forests, wetlands)
  - How does carbon sequestration potential vary among plant community types?
  - Monitor changes in distribution
  - Information on the physiological links between plant communities/functional types and climate that determine distribution
  - What are the effects of ecosystem drying on vegetation composition change?
  - Changes in phenology (greening/browning)
    - Identify phonological mismatch between vegetation and bird or mammal species
    - Effects of increased growing season on carbon sequestration, fire dynamics, soil moisture

- Determine effects of vegetation composition change on subsistence resources?
  - Harvestable vegetation species (e.g., berries)
  - Effects of changes in habitat for other subsistence species (e.g., moose, caribou)

- Vegetation species/communities range expansion (e.g., woody vegetation)
  - Treeline expansion northward/higher altitude
    - Effects on advancing treeline on carbon sequestration and fire (forest compared to tundra)

- Growth and yield curves for all tree species within LCC region to inform:
  - Predicted insect impact
Information need: Projecting future change in vegetation

- Vulnerability assessments of species/communities to climate change (e.g., spruce forests)
  - Forest communities (e.g., spruce forest)
  - Include effects of vegetation consumers and food-web effects
    - Vulnerability on species throughout the food web to projected changes in vegetation community composition and distribution (to establish monitoring program on trophic systems)
- Improved species-habitat models to understand links among species and plant communities (e.g., breeding bird habitat types and associations with plant community types, moose forage and early-successional forests)
- Correlations among severity pathogens/insect pests, climate, vegetation composition

Information need: Education and outreach

- How to inform the public about impacts on:
  - Subsistence resources
  - Commercial uses
  - Impacts on species of concern and non-consumptive spp, and their habitats

Wildfire

- Coordinate, gather, integrate, synthesize, share information and data on regional fire regime and fire management/fuel reduction efforts
  - Fire return intervals: past, present, future
    - Fuels reduction project mapping
    - Include TEK sources throughout all elements
    - Assess impact of land-use change (e.g., road building & land auctions to private) on fire management activities (suppression, prevention, etc.)
- Establish monitoring program for fuels reduction projects
  - Effects of fuel treatment, alternative fuels treatments (and effectiveness), fire break alternatives (and effectiveness)
    - Effectiveness of fuel-break techniques/science,
      - e.g., size, plant (Do stands killed or affected by leaf miner act as fuel breaks?)
      - Info on wetland drying and increased wildfire occurrence (wildfire mgmt / fuels reduction in former wetland areas);
      - How best address current/future wildland-urban interface fire risk?
    - Develop management options that produce less flammable forests/biomass
- Research effects of fire (severity, frequency, timing, etc.) on ecosystem features including:
  - Permafrost
  - Water temperature and quality (turbidity, sedimentation, etc.)
  - Fish and wildlife habitat and populations
  - Stand dynamics / vegetation change
  - Measure changes in carbon storage with wildfires
  - Subsistence uses
Revised List of Information Needs as of 1/11/13

Revised Information Needs List
While we have made every attempt to retain the integrity of each information need identified at the Management Framing Workshop, it was necessary to assemble a practical list of comparable elements. The process of refining of these information needs consisted of the three general steps described below.

1. At the workshop, the information needs were categorized by drivers of change. In many cases, there were duplicate information needs listed under different drivers. For example, baseline land cover and vegetation geospatial data were identified as needs under many different drivers. As a first step, we flagged all duplicate needs occurring in more than one driver of change.

2. We evaluated, clarified, and combined the information needs when appropriate.

3. During the workshop, participants expressed concern that some types of needs could not compare and compete well with other types of needs. To accommodate this concern, we searched for broad similarities with which the needs might be categorized and ranked. Five categories of information needs (or “bins”) were identified, under which the 105 distinct information needs were sorted.

Within each of these five categories, the workshop participants and the Steering Committee will compare and prioritize information needs of similar scale and scope, allowing us to avoid the comparison of “apples to oranges” in our ranking process.

Five Categories of Information Needs
In order to compare and rank like information needs, the shared information needs were separated into the following five categories. Workshop participants and Steering Committee members will rank all of the information needs within these categories using an online survey. Once the top-five information needs within each category have been identified using an online survey, Steering Committee members will convene on February 27 & 28, 2013 to discuss results of the survey and prioritize the top information needs overall. Prioritization will be conducted using the criteria developed during the Management Framing Workshop (App A., Table 6).

1. Baseline
These are information needs that support or enhance the LCC’s understanding of current system states. They may use existing data or involve new ways of using existing data. They may require collection of new data, or require synthesis of multiple existing datasets. They may be spatial or non-spatial in nature. Fundamentally, this bin includes information needs that define “Where we are, today.”

- High resolution land cover imaging to strategically focus geospatial data collection within the LCC with the following properties: Ability to distinguish among plant species (e.g., black spruce from white spruce, willows from alder)
- Assemble and develop Ecological Land Classification and mapping at multiple geographic scales (e.g. wetlands)
1. Baseline (Continued)

- Baseline data for vertebrate species, and populations, including species occurrence, diversity, habitat, threats, diet, susceptibility to change and human-caused disturbance, etc.
- Describe the current distribution, condition, and spatial extent of plant species/communities, (e.g., mapping of alpine biodiversity)
- Combined Canadian and US data (e.g., forest inventory data)
- Collect and make accessible available vegetation plot data from all US and Canadian public lands
- Coordinate, gather, integrate, synthesize, and share information on regional fire regimes and fire management/fuel reduction efforts. Shared data include the following: Past, present, fire return intervals and Maps of fuels reduction projects
- Address gaps in knowledge of pathogen or disease intensities in host populations in forests, and their impacts on forest health
- Gather baseline information on ecosystem functions of macroinvertebrates, (e.g., species abundance, diversity, habitats, relationship in food web, etc.)
- In the face of changing land uses, obtain baseline data on life histories, species habitat associations and suitability models for plant and animal species of concern (e.g., identify critical anadromous and freshwater habitat, migratory routes, spawning areas, and overwintering habitats).
- Correlated with changing land uses, obtain baseline data for species, habitats, and systems (e.g., land cover classification, wetland inventory, functional assessment, long-term stream flow and water quality parameters, archeological and cultural resource data mapping, permafrost decay).
- Baseline info for arthropod and macroinvertebrate species abundance, diversity, habitats, and food web relationships
- Consistent hydrological dataset for all of the LCC, across international border. Uses include the following: Salmon management, Pollutant transport studies and Investigating the spread of invasive species
- Develop improved Digital Elevation Models
- Improve the integration of permafrost data with other baseline data, and improve access to electronic datasets
- Investigate public perceptions about invasive species management strategies
- Map the location of existing anthropogenic disturbances (e.g., transportation infrastructure, trails, land use conversion, recreational development, timber extraction, gravel extraction, mining activity, and reclamation efforts.)
- Assemble publicly accessible database containing existing resource management plans, best management practices, restoration projects, etc.
2. Monitoring
These are information needs that support or enhance the LCC’s understanding of changes in system states over time. They may involve coordination or standardization of protocols or minimum data standards. They may reflect improvements to existing measurement systems or development of new measurement systems. Fundamentally, these are information needs that allow the LCC to track real world change in order to evaluate the accuracy of projections of future states and modify adaptation planning and best management practices. These information needs tell us “How systems are performing” and provide an essential feedback loop for landscape conservation.

- Recommend data sharing policies and procedures for LCC partner organizations, particularly across US-Canada border
- Evaluate effects of the changing growing season on distribution, abundance and productivity of species (including subsistence species/resources)
- Investigate effectiveness of new techniques of data collection for natural resource management (e.g., use of drones for updated aerial photography)
- Investigate the impacts of changing snow and ice dynamics on subnivian ecology
- Develop fine-resolution techniques to assess the spread of individual species (e.g., Elodea, Melilotus, bird vetch) to assess impacts on species of concern (e.g., subsistence resources, salmon, migratory birds, moose, T&E species), ecosystem services, and biological diversity
- Investigate the effects of fire suppression and fire management on the introduction and spread of invasive species
- Monitor the impacts of rain/ice/snow events on species(communities (e.g., ungulates, trees)
- Consistent forest inventory monitoring techniques and protocols between Canada and US
- Monitor the effects of changing glacial melt water discharge on habitat, population dynamics, and species diversity for important species (e.g., anadromous and resident fish, species important for subsistence and other human uses, ungulate species that rely on glaciers for insect relief, and riparian wildlife)
- Monitor changes in species phenology, abundance/density, productivity and survivorship (e.g., insect life stage development, plant flowering/fruiting, migration timing and prey availability)
- Monitor changes in plant and animal species distribution, abundance/density, productivity and survivorship as a result of growing-season length increases (e.g., tree line migration, shrubification of alpine tundra habitats; greening/browning of vegetation)
- Establish long-term insect impacts monitoring program across the region
- Monitor the spread of invasive species, including the following: Plants (merge AKEPIC GIS database with analogous Yukon/BC systems), Fish (such as northern pike in south-central Alaska and rainbow trout in Yukon), Invertebrates (the potential for mollusk invasion via road systems and float aircraft)
2. Monitoring (continued)

- Integrated parasite and pathogen monitoring program in fish and wildlife, especially subsistence and harvested species
- Using standardized monitoring protocols, establish baseline data for contaminants across the LCC region
- Monitor the impacts of temperature and precipitation change on phenology
- Increased monitoring of aquatic habitats in association with increase air temperature and ppt monitoring
- Establish monitoring program on trophic systems within forests and wetlands
- Monitor change in vegetation composition, phenology, productivity and carbon sequestration.
- Monitor changing vegetation phenology (i.e., greening/browning)
- Monitor fuels reduction projects and study their impacts. Impacts of interest include the following: Effects of fuels treatment, alternative fuels treatments, fire break alternatives (and effectiveness), Effects of fuel-break techniques and alternatives (e.g., effect of plant species and size), Effects of pest insects and pathogens on fuels and fuel breaks, and Links between increased wildfire regimes, wildfire management practices, and wetland dynamics/drying
- Improve mapping, modeling, and monitoring of permafrost location, depth, and freeze/thaw rates
- Monitor changes in glacial melt and glacial stream discharge, including the following parameters: Seasonal minimum flow, Rate of glacial surface change and volume, Quantity and timing of surface flow relative to public access, and Timing of seasonal melt water discharges into riparian systems
- Monitor riparian and floodplain change over time
- Improve snow monitoring (including phenology, depth, freeze/thaw events, rain on snow events)
- Collect standardized stream information on a sufficient number of watersheds to determine the impacts of temperature and precipitation change on flow and water quality at the landscape scale
- Increase weather station coverage to improve biome/climate association
- Investigate the impacts of site-specific land use conversion on critical habitats, such as wetlands.
- Investigate the human dimensions of natural resource management in the LCC, including the following: Village economics, Patterns of migration, Land use change, and Trends in recreation, non-consumptive uses and expectations of natural assets
3. Understanding Relationships
These are information needs that support or enhance the LCC’s understanding of relationships within current systems. These may involve experimentally-derived conclusions or analysis of existing empirical data. This information is necessary to project future states (based on anticipated changes). This bin also includes information needs that explain “How or why systems function.”

- Investigate the impacts of temperature and precipitation change on phenology
- Baseline information for ecosystem functions and trophic relationships, (e.g., lichens and mosses),
- Evaluate links between changing growing seasons and fire seasons
- Determine the effects of pest insects on trees and traditional foods (parameters include range expansion/decrease, outbreak timing, new habitat penetration)
- Investigate the factors that limit pest insects (e.g., low precipitation, thin cambium, ecological restrictions, winter minimum temperatures)
- Investigate the impacts of marine stressors (e.g., acidification, pollution, overharvest) on marine nutrient transport to freshwater and terrestrial ecosystems.
- Address gaps in knowledge of parasite or disease intensities in host populations of fish and wildlife, and their impacts on species’ health and population dynamics
- Investigations into physiological temperature thresholds that link climate suitability to specific species
- Investigate the effects of climate change on freshwater fish and other subsistence species and resources
- Impact of vegetation composition change on subsistence resources (e.g., harvested vegetation, ungulates, etc.)
- Investigate growth and yield curves for all tree species and correlate with insect population dynamics, biomass, timber, and carbon sequestration
- Assess the vulnerability of forest species and communities to climate change, including vulnerability of species throughout food webs
- Investigate possible correlations between severe pathogen or pest insect infestations, climate, and vegetation composition
- Investigate how carbon sequestration potential varies among plant community types
- Investigate the physiological links between plant communities/functional types and climate to determine biome distributions
- Investigate the effects of ecosystem drying on vegetation composition change?
- Investigate potential phenological mismatches between vegetation and bird or mammal species
3. Understanding Relationships (continued)

- Investigate the effects of longer growing seasons on carbon sequestration, fire dynamics, and soil moisture
- Investigate the effects of fire on ecosystems processes (e.g., severity, frequency, and timing), including the following: Permafrost dynamics, Water temperature and quality (turbidity, sedimentation, etc.), Fish and wildlife habitats and populations, Stand dynamics and vegetation change, Changes in carbon storage, and Subsistence and other consumptive uses of fish and wildlife
- Investigate the effects of contaminants and pollution on public health, harvested species and other species of concern

4. Projecting Future System States

These are information needs that support or enhance the LCC’s understanding of potential changes in system states, based on modeling future conditions. They may include impact models, distribution models and downscaled climate information. Model products may be spatial or non-spatial in nature. Fundamentally, this bin includes information needs that predict “Where we are headed” given various future scenarios.

- Assess and project range of changes in prevalence and distribution of parasite and pathogens in fish and wildlife, e.g., link fish & wildlife pathogen life cycles to regional climate model projections
- Assess and project range of changes in prevalence and distribution of parasite and pathogens in forests (e.g., link forest pathogen life cycles to regional climate model projections)
- Investigate possible vectors, vulnerabilities and probabilities for invasion of dangerous species to the NWIF LCC
- Investigate how changes in temperature and precipitation regimes may affect vegetative productivity via temperature-induced drought stress, longer growing seasons, less water availability (higher evapotranspiration)
- Investigate the possible range expansion of woody species, and the possible impacts to rates of carbon sequestration, wildfire frequency and wildfire impacts
- Project the impacts of rain/ice/snow events on species/communities (e.g., ungulates, trees) and their effects on population trends
- Project future wildfire return intervals, link with fuels reduction projects
- Project future species distribution, abundance and phenology under various climate change scenarios
- Project changes in the impact of insects under various climate change and land use change scenarios (species of interest include spruce bark beetles, IPS, and moose ticks)
- Develop damage models for pest insect outbreaks, focusing on tree-killing species
- Project the effects of climate change on the spread of and pathogens for the LCC.
4. **Projecting Future System States (continued)**

- Project future vulnerability to land-use change, including projected changes to human access and resource exploitation (e.g., recreation, mining, timber extraction), and effects of cumulative disturbances in a changing climate on ecosystems, cultural resources, and focal species (e.g., habitat fragmentation, location/spread of invasives)

- Predict changes in marine nutrient transport and their effects on habitat, populations, and diversity of anadromous and resident freshwater fish

- Predict the impacts of increasing temperatures on vegetation, snow/rain events, insect hatches, parasite and pathogen range expansions, and the cumulative effects of these factors on ungulates

- Projections of habitat change that pair anticipated climates with ecosystem features in analogous environments

- Project changes in plant species, community composition, and ecosystem processes as a result of climate change

- Investigate and predict the range expansion or range decrease of plant species and communities under various climate change scenarios, and describe the species and communities will be replaced or excluded

- Improve species/habitat models to include links between species and plant communities (e.g., breeding bird habitat types and associations with plant community types, or moose forage and early successional forests)

- Project changing distributions of species and communities

- Develop a water budget model as a decision tool to evaluate hydrological basins

- Model riparian and floodplain change over time

- Predict and map the impacts of changing permafrost dynamics on the following: Hydrology-surface and subsurface, Wetlands, Lakes, rivers, streams (including connectivity), Biochemistry, Land use management, Species habitat and populations, Water quality and quantity, Terrestrial plants (forests), and Human use; public safety/health

- Develop predictive models that examine changes in hydrology and impacts to wetlands as a result of changing permafrost dynamics

- Develop predictive models that indicate changes in carbon storage as a result of changing permafrost dynamics
5. Adaptation Planning and Best Management Practices

These are information needs that support or enhance the LCC’s understanding of the actions needed to move toward a desired future system state or condition, given current knowledge of “Where we are, today,” “How and why systems work” and “Where we are headed.” The information needs in this bin pertain to the conception or implementation of local to regional adaptation strategies. This includes the creation of Best Management Practices or alternative management scenarios, and decision support to identify “Where do we want to go, and how do we get there.”

- Develop management strategies for alleviating tree stress
- Develop management protocols for potential future invasive species
- Methods for protecting ecosystem functions and tropic relationships (e.g., lichens and mosses)
- Best management practices for determining the appropriate size, desired species etc. of riparian, wetland and shoreline buffer areas.
- Best management practices for protecting/informing wildlife corridors in developed areas
- Develop management options for producing less flammable forests and biomass
- Is it possible or feasible to offer carbon credits for boreal forests?
- Develop inclusive decision-making processes for managing new or expanding land uses
- Best management practices for addressing current and future wildland/urban interface fire risk
- Establish best practices for informing the public about the impacts of climate change on subsistence resources, commercial uses, non-consumptive species, habitats, and species of concern