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INVENTORY OF ECOSYSTEM INDICATORS IN CANADA'S NORTH FOR THE NORTHERN ECOSYSTEM INITIATIVE

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Prepared by
Peter Hardi and
Marlene Roy

Prepared for
Environment Canada
Northern Corporate Affairs
Suite 301, 5204-50th Avenue
Yellowknife, NT
X1A 1E2

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1. Background

Environment Canada supports six ecosystem initiatives in Canada. The Northern Ecosystem Initiative (NEI) is one of the six and focuses on supporting partnership-based approaches important to the conservation, protection and restoration of northern ecosystems and sustainability of northern communities. The scope of the NEI includes the Yukon, Northwest Territories, Nunavut, lowlands in northern Manitoba and Ontario, northern Quebec and Labrador, i.e. "Canada's North".

Beginning April 2003, NEI was renewed for a second, Phase II, five year mandate. Under Phase II, NEI has five program priorities related to:

1. Better understanding and adapting to the ecosystem impacts of *climate change*;
2. Better understanding and managing ecosystem impacts of *contaminants*;
3. Better understanding and managing the *cumulative effects* of development activities;
4. Building our shared *capacity* (community, research and government); and
5. Supporting the establishment of a *northern monitoring network* able to provide status and trend information.

This work falls under the fifth program priority: supporting the establishment of a northern monitoring network. Important elements underlying this priority include supporting efforts to make the status and trend information more readily accessible and of use (understandable) to northern communities, planners, policy and decision-makers and the general public; and, to the extent possible, ensuring the northern monitoring network is consistent with and supportive of Canada's commitments under the Arctic Council and other international fora where issues of significance to the Canadian North are addressed.

To strategically move ahead on that priority, NEI required an overview report and annotated inventory of existing ecosystem indicators in the Canadian North. The report consists of two main components: 1) an inventory overview and synthesis of findings and 2) annotated bibliography of existing ecosystem indicators. Supporting documents include tables of indicators, records of interviews and list of contacted persons and initiatives.

2. Review of Northern Ecosystem Indicators

Environment Canada provided guidance on the scope of the inventory, leading to several "soft" criteria to identify ecosystem indicators that were used by the researchers. These criteria are described below along with some of the issues encountered by the researchers in applying them.

Geographic Scope

Over three hundred ecosystem indicators were identified with most falling within and/or across the jurisdictional boundaries of the Yukon, the Northwest Territories and Nunavut. In some instances, ecosystems included northern areas of British Columbia (e.g., Mackenzie basin); Alberta (e.g., Mackenzie Basin and Beverly and Qamanirjuaq Caribou Range); Saskatchewan (e.g., Beverly and Qamanirjuaq Caribou Range); Manitoba (e.g., Beverly and Qamanirjuaq Caribou Range and Hudson Bay Traditional Knowledge); Ontario (e.g., Hudson Bay Traditional Knowledge); Quebec (e.g., Hudson Bay Traditional Knowledge); and Labrador (e.g., Hudson Bay Traditional Knowledge). In addition, indicators from the Hudson Bay region were selected, as were those for climate change in the circumpolar Arctic, if they were disaggregated for the Canadian north.

As ecosystems often cross jurisdictional boundaries, it was necessary to decide the basis for their inclusion when the ecosystem was largely situated outside of northern Canada. This was the case with the Northern River Basin Study; most of the ecosystem was situated in Alberta and it was decided to exclude it on this basis. The situation was different for the Porcupine and Beverly and Qamanirjuaq Caribou ranges; in each of these cases, significant areas of the caribou range fell within the geographic scope of the inventory and hence, were included.

Time Scale and Historic Length

Finding ecosystem indicators developed prior to the early 1990s proved to be challenging, mainly because adequate documentation could not be readily found. For those that were found for which verification is possible, the historic length of the data was noted.

Some of the ecosystem indicator initiatives and indicators were developed to provide baseline data. As the researcher could not determine if the intent was to continue with data collection (i.e., monitor change to the ecosystem over time), they were included, as they still provided valuable information about ecosystems that could be used for other purposes.

Ecosystem Indicators: Ad hoc Descriptive Criteria

Before embarking on the inventory, it was necessary to sketch out a working definition of ecosystems and ecosystem indicators. Hence, several definitions were sourced and considered. One article, recently published by Yolanda F. Wiersma in the journal *Environmental Monitoring and Assessment,* proved to be very useful. In this article, Wiersma (2005) compares the new concept of ecological benchmarks to that of more widely used environmental benchmarks with which Canada has a fair amount of experience. While this analysis provides insight into the definition of ecological indicators, the author notes that "ecological benchmarks and their corresponding indicators will be challenging to identify and use" (Wiersma 2005, 1).

In the same article, Lynch-Stewart (2002 in Wiersma 2005, 2) observes that ecological benchmarks are "based on the importance of ecosystems in general—or specific sites, types, attributes of functions—to the surrounding environment or landscape." Indeed, these characteristics of ecosystems were evident in all ecosystem definitions reviewed by the researchers; all referred to interactions between organisms and their physical environment. This defining aspect of ecosystems is further elaborated by Wiersma (2005, 4) who argues that "if environmental benchmarks represent a state in the abiotic environment that allows organisms to persist, then ecological benchmarks represent some kind of state in biotic environments that allows organisms (human, or other) to persist," a distinction which provides an important criteria for selecting ecosystem indicators. Based on Wiersma's article and review of ecosystem and indicator definitions, several ad hoc descriptive criteria were developed to guide the researcher in identifying ecosystem indicators.

Ad-hoc Criteria for Inclusion

Wiersma (2005, 4) notes that ecological benchmarks are quantified using indicators (such as species richness or forest structural complexity). Other characteristics that were used as criteria and noted in the same articles include:

1) Does the ecosystem indicator set track natural ecological processes such as competition, predation, succession, dispersal, speciation, etc.?
2) Are the ecosystem indicators location-specific in that they can be identified for specific regions and ecosystems?
3) Other criteria for ecological indicators include (Boyle 1998 and Wiersma and Campbell 2002 in Wiersma 205, 6, 7):
    a) Appropriateness for ecosystem (site-specific);
    b) Whether it provides information about the system (detect positive and negative change);
    c) The efficiency and cost-effectiveness of the indicators; and
    d) Whether the set of indicators is comprehensive. Is there a suite of biotic, abiotic, human use and values indicators? E.g., boreal forest: effects of forest harvest or habitat fragmentation; biotic indicator: presence of species dependent on forest; and abiotic indicator: soil or water quality.

Ecosystem indicator initiatives and, of course, indicators were not *selected* based on the comprehensive criteria listed above in item 3.d, but the researchers thought that it would be useful to assess the completeness of a set of ecosystem indicators. Hence, we adopted the comprehensive criteria outlined above in item 3.d and assigned keywords to individual indicators as to whether they are biotic, abiotic, human use or values indicators. Groups of indicators were then assessed at the scale of the ecosystem to determine how comprehensive they are and then measurement gaps were identified.

Exclusion Criteria

Based on the above ad-hoc criteria and building on the definition of an ecological indicator from MacDonald Environmental Services Ltd. (1994, 23) which is "a feature of the environment which provides managerially and scientifically useful information on the quality of the ecosystem as a whole," the following types of initiatives and programs were <u>not</u> included:

those that had only abiotic indicators and measures that did not consider impacts and/or interactions with living species (e.g., water quality indicators);
those that did not provide information about the ecosystem(s) within the geographic scope of the analysis. An example would be environmental reports that did not include information about ecosystems within the reporting jurisdiction or did not include indicators and measures disaggregated for northern Canada. For those ecosystems crossing into provinces, only those with more than approximately one quarter to one third of their area in the north were included;
those that did not have clearly stated indicators and measures; and
those for which we could not obtain adequate information on the indicators and measures (e.g., initiatives and programs undertaken in the 1980s that are referenced, but for which information could not be sourced within the time frame of the project).

Literature Search Method

The literature search was complex and comprehensive; over three hundred Web pages, and 17 reference databases were scanned for ecosystem indicators that met the ad-hoc criteria. The goal was to be as thorough as possible so that any gaps in the EMAN North Information Centre database could be either verified or filled.

The first step in the literature search was to scan several reference and library databases that would likely hold references to northern ecosystem indicators using appropriate search terms. This was followed by a Web site search of those organizations working in northern Canada and likely to have ecosystem indicator initiatives. Both of these activities are described in more detail below. A list of the reference and library databases and organizational Web sites searched is in Section 7.

1. *Search of reference and library databases (number searched = 17).*
   Reference and library databases were searched for articles and reports using several keyword search terms including: ecosystem(s), indicator(s), taiga, tundra, Arctic, environment, northern regions, boreal, Yukon, Northwest Territories, Nunavut and various combinations of these and others, as determined by the requirements of the database. From this initial database search, over 100 references to articles, books and organizations that might have information on ecosystem indicators were identified and listed in a citation bibliography with the most promising selected for follow-up. From among those selected references that pre-dated the World Wide Web, some were requested through inter-library loan from other library holdings (three cases); government publications were requested from the appropriate government department (three cases); and several were available in IISD's library. The remainder were sourced on the World Wide Web by searching publication holdings of organizational Web sites, and several articles were obtained through electronic journal databases using the University of Manitoba system. Bibliographies in more than 50 per cent of the sourced publications were searched for additional references.

2. *Organizational Web site searches (number searched = 66 X 5 - 10 web pages at each Web site)*
   Several organizations working on ecosystem indicators were identified through the

database search, providing a starting point for doing WWW searching. The Web sites of these organizations were searched by looking through lists of organizational publications and by reading Web page information on programs and projects. Those publications that were relevant were either printed or ordered by telephone. Frequently, these Web sites had links to other organizations and initiatives, which were also searched.

The literature search found 22 ecosystem indicator initiatives. (Two were sourced through interviews.) Relevant information has been gathered for each initiative and is described in an annotated bibliography. As each initiative has multiple indicators, each ecosystem indicator has been also listed in an Excel spreadsheet which is available electronically. Where possible, the years of data collected and location of the monitoring have been listed along with the ecosystem indicator. As of February 7, 2005, over 330 ecosystem indicators have been entered into the spreadsheet.

3. Analysis of the Results of Inventory Review and Interviews

Our review of the numerous Northern initiatives to measure the different components of the Northern Ecosystem consists of two parts:

1. An annotated bibliography of printed and electronic materials; and
2. An analysis of the findings, discussing the current situation and making suggestions for future work.

The annotated bibliography is presented in Section 6. This section presents the analysis of our findings. It includes a discussion of the characteristics of the ecosystem to be monitored, the process to be used in designing and applying ecosystem indicators in the North, and the characteristics of the indicators to be applied. It also provides a summary of the expectations from the present inventory project. The analysis ends with a list of planned and/or suggested indicators for the Northern ecosystem, as indicated by the interviewees.

The review, while successful in covering a wide range of individual research and monitoring projects, has been disappointing in light of the expectations expressed in the Terms of Reference of the project, and as reflected in the investigative template we have developed for the review. In summary, we may conclude that the richness of individual projects has not been matched with the expected coherence and depth of information, with expected significant findings on indicator frameworks, aggregation mechanisms, integrations and the existence of truly broad, systemic indicators. This finding is not surprising given that most investigators only have a cursory understanding of indicators, and consequently did not design their studies with the rigour required for our analysis. Obtaining trend information using consistent frameworks is indeed challenging. Often there are no clear frameworks used thereby making it difficult to aggregate and develop indicators for the purpose of reporting on the state of the Northern environment. The lack of substantial information in these areas made the coverage of several themes of our expected analysis impossible. With one or two exceptions, we could not meaningfully identify measurement frameworks and/or models used in the projects; consequently, we could not analyze similarities and differences among models and approaches. Most of the research and indicators reviewed here are based on, and driven by, issues and by environmental media. Very few reports have used Pressure-State-Response in reporting environmental information.

We could not discuss weighting and aggregation methodologies as these or other indicator development processes have not been used in the reviewed initiatives. The compilation of indicators and variables reviewed could help us outline an indicator typology only in a very general sense. We identified methodological limitations; data and information gaps; and a few best practices. We could also draw on some of the lessons learned by those who provided us with information on the different initiatives, and we included these lessons into our analysis.

We were hoping to find ecosystem indicators that could be used to measure those partnership-based objectives that the Northern Ecosystem Initiative (NEI) is focusing on, namely approaches important to the conservation, protection and restoration of Northern ecosystems and sustainability of Northern communities. Our conclusion is that the existing information generated by monitoring programs and by the collected variables, data and other forms of qualitative and quantitative information; the existing networks and institutional arrangements; and the overall

design of integrating these efforts, are only partially adequate to meet the stated expectations of the NEI, namely:

1. To provide science in support of ecosystem sustainability;
2. To lead and act as a catalyst in mobilizing partners to address sustainable development; and
3. To build the capacity of communities to better understand the key ecosystem stresses and make environmentally sound decisions.

What is clearly missing from the picture is a "state of the environment (SOE) report" for the North to help identify critical factors, including driving forces, pressures, impacts and responses—components of a framework that is frequently used in SOE reporting. An SOE report would enable the identification of what some of the gaps are in terms of issues that have been identified through the policy process.[1]

Perhaps the single most important impediment is the lack of integration in the design phase of the different programs and during the processing of information on the different characteristics of the ecosystem. We have designed our review framework so that the fifth program priority of the NEI (i.e., supporting the establishment of a *Northern monitoring network* able to provide status and trend information) would create a monitoring network that would operate simultaneously as an instrument that channels information to those who work on the other priorities and as an integrative tool that helps connect these priorities. This design reflects a holistic approach to ecosystems that transcends the narrower interpretation of ecosystems as natural environments.

I. Broader interpretation of ecosystem

The study of human/community indicators was beyond the scope of the inventory, but we have received regular feedback on the importance of including community health as one of the indicators of ecosystem health. This is a particularly important indicator if we are looking at the conditions of sustainable development. Many interviewees emphasized the importance of considering the interpretation of ecosystem beyond its narrow, internal (nature-focused) definition, and instead adopt a broader, more holistic approach (that better relates to sustainable development) to include external stressors as well. This would be consistent with the approach taken in other areas of the country, e.g., the Great Lakes, St. Lawrence, etc. Some of the interviewees identified such externally imposed stressors as:

climate change;
toxic pollution;
economic activity stressors; and
social stressors.

These stressors are identical with the priorities of the NEI. Systemic thinking requires that these stressors should be analyzed when we discuss the ecosystem, and people should be viewed as part of the ecosystem. This is especially true for the North where people tend to be more connected to nature than in more southern areas. For instance, stressors would include resource

[1] Some SOE type of reports in which indicators are reported do exist: Yukon SOE, aquatic assessment for the Mackenzie Basin, etc. There should be more SOE type of reports to help meet the NEI goals.

use indicators since many of the pressures that the North is facing are driven by the world's need for oil and gas—clearly creating stresses on land development and the social structure.

II. Process characteristics of indicator construction

There is a need to link monitoring to a broader reporting framework to ensure that all of the environmental information gathered from monitoring programs, science-based assessments and indicators can be integrated and interpreted to provide a consistent structure for comprehensive, credible and continuous reporting. Most of the scientists, who monitor different characteristics of the North and collect variables, are interested in indicators only in an indirect sense, not in the context of their own research. At the same time, they acknowledge the importance of processing their scientific information into a more usable form for decision-makers and managers. Consequently, they are interested in seeing a scientifically satisfactory *process* of developing indicators. According to their views, the process characteristics are the following:

1. Establish a high degree of statistical relevance

Some of the indicators lack relevance to policy-makers and does not meet user needs. There is no comprehensive picture of environmental conditions, pressures or societal responses in this geographic area other than what was produced 10 years ago through the State of Canada's Environment. In order to make indicators scientifically relevant, the following issues should be addressed:

1.1. Need for a *baseline* that, in most cases, does not exist, and need for an observational system/network that is capable of establishing reliable historic data (historical observation is, in most cases, very patchy).
1.2. The *statistical reliability* of an indicator requires a high frequency of measures in time—i.e., the ability to establish time series—and a high density of measure in space. These conditions require more emphasis on the ability to monitor individual variables over time in order to better understand trends and natural variability of the observed data.
1.3. The North is a *highly dynamic space* where measurement and monitoring are needed for a reasonably long time and with reasonably high density. Current data are patchy and have low density because of costs of monitoring stations and instrumentation. Inability to do much is due to scarce resources and inconsistent government support.

Beyond the scientific needs, there are organizational issues that have been highlighted as necessary elements of indicator construction:

1.4. Need for *institutionalization*: An additional problem (beyond scarce resources) and beyond participants' control is the lack of institutionalized structures; institutions are participating in monitoring only because of individual commitments. This situation needs to be changed.

All of the above points speak precisely to why NEI is looking at a pan-Northern monitoring program, based on indicators (and reflecting the understanding that "you manage what you measure").

2. Design and implement monitoring in a multi-stakeholder process

Most often, the links to *decision-making* are not factored into the design methodology of monitoring and indicator work. The findings indicate that observation science is increasingly left to universities (scaling federal programs back) but they are conducting more project-related studies. There is a need for applied monitoring, but most monitoring is designed for scientific goals. Reporting needs to be policy driven, hence, if a policy question is asked such as "is the water drinkable or is the food safe to eat?" then it becomes relevant for the various stakeholders involved in the development of monitoring activities or indicator development.

The design of monitoring must be scientifically sound, while the primary objective of government monitoring programs is to support decision-making. In addition, this focus will enable us to see whether progress has been made on these policy questions and, if necessary, establish monitoring programs to bridge any information gaps. The advice emphasizes the following:

2.1. Scientific design of monitoring needs to be complemented by *management and decision-making-related* objectives, e.g., monitoring wildlife for management programs (population and harvest rates are observed for key species for harvest management).
2.2. *Community* involvement and outreach is crucial: design of monitoring must ensure meaningful local participation, understand limits of participation, and needs benchmarks and identification of critical thresholds (e.g. compensation, time allocation, paid vs. voluntary participation).
2.3. Monitoring program managers are often struggling for *buy-in* from potential supporting and advocacy organizations to convince them that there are good data that they need. Positive outcomes, local employment and training opportunities are important conditions of success (e.g., these are criteria for funding wildlife monitoring programs).
2.4. *Tensions* may arise between scientists and locals (community members, local stakeholders) because of different interpretations of monitoring needs. This tension may hinder the proper implementation of monitoring programs; discussion of expectations and different priorities is necessary already at the design and start of the programs.
2.5. *Success* of EMAN-N: improve and facilitate monitoring activities and conditions, provide venue for exchange—it serves as a good model for other programs.

3. Use aggregation for developing indicators and indices

Scientists and local stakeholders alike use, almost exclusively, measurable variables or data, even if sometimes these are called indicators. True indicators (constructed from measured data to characterize the system) are very rare exceptions. There is no mechanism in place to integrate disparate data that would be useful for policy-makers (even though it is needed, e.g., for comprehensive SOE reports for Nunavut and NWT, one of the long-term goals of NEI). According to the National Indicators and Reporting Office (NIRO) of Environment Canada, indicators are defined as statistics that demonstrate trends in the condition of a phenomenon. Environmental indicators focus on trends in environmental changes, stresses causing these changes, how ecosystems (including humans) are responding to these changes, and societal responses. Hence, there are a number of indicators that do exist, however, they

may not have been developed with a policy focus There is no mechanism in place to integrate disparate data that would be useful for policy-makers (even though it is needed, e.g., for comprehensive SOE report for Nunavut and NWT).

3.1. *Lack of aggregation*. Without aggregation the individual data look more like a shopping list of independent (and seemingly unrelated) variables.

3.2. *Data processing*. The data question is indeed a big issue and is often driven by frameworks used to analyze environmental and socio-economic data that are collected from a number of agencies, using different methods of classification and for different purposes. The key areas on which to focus are:

- data quantity/quality;
- data access/dissemination;
- data synthesis/integration; and
- data comparability.

There is a very limited ability for processing individual variables into indicators and/or indices. Processing is hindered by the lack of common framework and standards. National EMAN is much farther ahead in standardization efforts and in use of agreed core variables than EMAN-North. There is no discussion yet on how we can define reproducible indices and use them in combination with other data/information. Different variables that combine an index need to be measured regularly to understand stochastic processes.

3.3. *Potential to aggregate*: Focus is on monitoring activities, not on indicators, but:

ArcticNet: Individual thermodynamic variables that are regularly measured now could be aggregated into system indicators (consistency in several measurements is now based on space measures);

EMAN-N: Next natural step: Create indicators

- Natural because monitoring provides background for indicators, establishes datasets and time trends;
- Missing for next step to become reality: Money; human resources; will power of decision-makers; and
- Also needs a framework to guide indicator work.

NCP: It has a framework and provides time trends for developing elements into indicators to be used to track progress and change.

III. Indicator characteristics

1. Functions of indicators

1.1. *Be relevant:* Lots of data and several ecological indicators exist for the North, but it is arguable how relevant they are from the particular perspective of ecosystems. A link with policy is necessary in order to make the indicators more relevant.

- There is no cross-jurisdictional, boundary-type general information; data are collected differently, in different GIS formats, that are not applicable for a common database. Data sets are not brought out as indicator products or outputs, and no synthesis points are provided, except: Parks Canada.

- *Biases*: Scientific: Indicators should help people understand, not manage the system. Decision-making: Indicators should help manage the system and design response. These objectives need to complement each other.

1.2. *Inform a general audience:* On the rate and kind of change in the system. (This is an important reason to transform data into indicators.)

1.3. *From decision-making perspective*: Ecosystem indicators have several important functions:

Advise Northern communities for best adaptation strategies
Decide whether acting is needed locally, regionally or globally
Help rightly dispose energy of actors: How to compare the benefit of actions
Help decide how investments to achieve change should be made with better payoff.

2. Candidate variables for aggregation as identified by practitioners

Several researchers identified different factors in their work that could be used in developing aggregate indices. Almost all of these relate to climate change issues. Variables that could help define ecosystem indicators include:

- Sea-ice parameters in general
- Primary production at the base of the ice (i.e., algal growth) and secondary production (melt of sea-ice) combined: good ecosystem health indicator
- Expanded geographic coverage for temperature and precipitation information
  - For snow density and depth (no snow cover observation yet)
  - For sea-ice cover

3. Integration

Integration is a key concept in a holistic approach to ecosystems and an indispensable factor in sustainable development strategic planning and implementation. Integration of information, design, institutional and knowledge management is a strongly emphasized need, repeated frequently during the interviews.

3.1. There is a great *need for integration* of Northern climate change observation and data in order to interpret information for the North as an ecosystem and its changes. Integration requires:

- International standardization of monitoring programs
- Standardization of monitoring methodology

Both are missing; efforts are needed to make them happen. It is important to make the results compatible with international findings.

3.2. *Interdisciplinary integration* on Northern ecosystem level: A necessity for explaining the system across disciplines and for synthesizing information.

ArcticNet as a positive example: It integrates programs across disciplines to explain:

- Climate driven changes;
- Environmental changes; and
- Last five years: breaking barrier in integrated research.

3.3. *Challenges* include the fact that spatially varying pieces of information based on most diverse data are to be integrated. Ways to integrate depend on economic and social questions that we try to manage.

IV. Expectations from inventory project

Most comments that have been made by the contacted experts should be interpreted as statements of missing elements in current programs and ongoing work, based on the experience and analysis of those involved in monitoring, data collection and use of information based on measurements in the North. The following is a summary of different but often coinciding observations:

Fill a critical gap of knowing who's doing what and where.
Provide a final list of indicators and how they are used in different jurisdictions for assessment and management, as well as how they are used in the context of performance reporting.
Help identify most general clusters of grouping indicators. Find common features of indicators and help define indicator criteria in order to develop reproducible, stable indicators with the capacity to explain statistical variations. Clusters of indicators make sense if a particular framework is used. There are different frameworks to be considered, as is demonstrated by NIRO.[2]
Make data sharing possible.
Overcome fragmentation by scientific, management and policy-making needs: Gather together scientists, managers, policy-makers and local groups to brainstorm about what would be the best grouping.
Provide feedback for planned overview of monitoring; monitoring overview to continue and complement indicator inventory.
Provide help on how to use existing information centre materials from the point of view of indicator framework development and from publications' purposes (what people need).
Some data sets hang out in isolation, but no reason to abandon monitoring, even if current data are scarce, such as polar bear population.

V. Suggested/planned new indicators for the Northern Ecosystem

Beyond the numerous indicators collected and listed in the database, the interviewees have also identified *candidate indicators* that are not yet used or developed, but were mentioned during the interviews. Most of the suggested indicators focus on climate change issues, while other areas focusing on nature are not mentioned.

[2] NIRO has traditionally used the Pressure-State-Response framework; however for the ES 2005, it is considering reporting the information using a number of frameworks including the Driving forces, Pressure, State, Impact, Response, Environmental Sustainability (e.g., conserve biodiversity); Medium (e.g., air, nature); Planetary Human and Economic Health, Performance Measurement.

1. *Health of Northern communities* – human health and community health are the best indicators of ecosystem health

- The importance of the human dimension in the ecosystem:
    - Human, biotic and abiotic dimensions are more tightly coupled in the North than anywhere else
    - Life directly depends on the other dimensions that characterize the ecosystem

2. *Candidate climate change indicators*:

- Records of transition in soil moisture and temperatures and air temperature can be used as an *index of seasonal change;*
- Data on moisture availability to plants can be used to create a *dryness index;*
- Based on the influence of temperature-precipitation-climate variables, an *index of snow condition* can be developed; and
- Based on climate change and its effect on river conditions such as overflow, an *index of river ice condition* can be developed.

In several cases, researchers could provide information on planned activities to develop and/or use new indicators:

3. *Arctic Borderland Ecological Knowledge Co-op planned indicators*:
   - Add new regional information for North Yukon;
   - Expand geographic coverage for temperature and precipitation info:
       - For snow density and depth (no snow cover observation yet); and
       - For sea-ice cover; and
   - Add stressor indicators (e.g., beluga monitoring by aircraft over-flights).

4. *Northern Research Institute planned indicators:*
   - New indicator will be developed through rapid bio-assessment of the structure of invertebrates to assess the environmental integrity (water quality and stressors) of streams;
   - Index construction is possible on the basis of existing indicators.
       - Index of snow condition, based on the influence of temperature-precipitation-climate variables;
       - Index of river ice condition (based on climate change, effect on river conditions such as overflow); and
       - How physical variables influence biological variables:
           - e.g., snow levels effect on caribou movement; and
           - how these impact humans, e.g., travel across land

As a general guideline, we need to have policy questions answered to give direction to the indicators that will be reported on and this will help to highlight what monitoring gaps exist and how to fill these gaps in the future.

4. Northern Indicator Initiatives (Summary Table)

Title of Indicator / Programme	Link to Full Bibiographic Record	Year(s) of Initiative	Indicator development process (Local, Traditional / Scientific / Both)	Ecosystem type	Scale: Community, Regional or Pan-northern
Aklavik Inuvialuit describe the status of certain birds & animals on the Yukon North Slope, March 2003	biblio aklavik tek.doc	2003	Local, traditional	Terrestrial, coastal	Regional
Arctic Borderlands Ecological Knowledge Co-op Indicators	biblio arctic borderlands.doc	1994 - ongoing	Both	Coastal, freshwater, northern river basins, marine and terrestrial	Regional
Arctic Change: a near real-time Artic change indicator website	biblio Arctic change.doc	n/a	Scientific	Coastal, marine, terrestrial	Pan-northern
Arctic Seabird Monitoring Program	biblio arctic seabird.doc	1975 - ongoing	Scientific	Marine	Pan-northern
ArcticNet Theme 2 (note: list of indicators not sent)	biblio ArcticNet Theme 2.doc	2004 - ongoing	Both	Terrestrial	Pan-northern
Climate change impacts on tundra ecosystems (CANNTEX)	biblio canttex.doc	1990 - ongoing	Scientific	Coastal, northern river basin, terrestrial	Pan-northern
Holman Seal Monitoring Project	biblio Holman seals.doc	1971 - ongoing	Both	Marine	Regional
Hudson Bay Traditional Ecological Knowledge and Management Systems (TEKMS)	biblio hudson bay tek.doc	1992 - 1995	Local, traditional	Hudson Bay bioregion; coastal, marine	Community
Inuit bowhead knowledge study	biblio Inuit bowhead.doc	1915 - present	Local, traditional	Marine	Regional

Title of Indicator / Programme	Link to Full Bibiographic Record	Year(s) of Initiative	Indicator development process (Local, Traditional / Scientific / Both)	Ecosystem type	Scale: Community, Regional or Pan-northern
Inuvialuit traditional ecological knowledge of fisheries in rivers west of the Mackenzie River in the Canadian Arctic (TEK Fishing study)	biblio TEK fishery.doc	2002 - 2003	Local, traditional	Freshwater	Regional
Kluane Alpine Ecosystem Project	biblio kluane alpine.doc	on-going	Scientific	Terrestrial (alpine)	Regional
Kluane Boreal Forest Ecosystem Project	biblio kluane.doc	1986 - ongoing	Scientific	Terrestrial	Regional
Lower Hyland River Wildlands Study	biblio Hyland River.doc	2001	Scientific	Northern river basin	Regional
Mackenzie River Basin State of the Aquatic Ecosystem	biblio mackenzie.doc	1997 - ongoing	Both	Northern river basin	Regional
Mortality of Moss	biblio moss mortality.doc	2003 - ongoing	Scientific		Local
Northern Contaminants Program Projects for 2004-2005	biblio northern contaminants.doc	1991 - ongoing	Scientific	Coastal, freshwater, marine	Pan-northern
Protecting the Beverly and Qamanirjuaq Caribou and Caribou Range	biblio BQCMB.doc	1982 - ongoing	Both	Terrestrial	Regional
Rat River biodiversity, cultural and Historical assessment	biblio rat river.doc	1999	Scientific	Northern river basin	Regional
Research and monitoring of Canada's protected heritage	biblio parks west arctic.doc	n/a	Both	Terrestrial	Regional

Title of Indicator / Programme	Link to Full Bibiographic Record	Year(s) of Initiative	Indicator development process (Local, Traditional / Scientific / Both)	Ecosystem type	Scale: Community, Regional or Pan-northern
Terrestrial trophic dynamics in the Canadian Arctic	Biblio Tundra exped.doc	1999 (summer)	Scientific	Terrestrial	Pan-northern
Wapusk regional ecosystem	biblio Wapusk Regional Ecosystem.doc	1998 - ongoing	Scientific	Terrestial, coastal	Regional
West Kitikmeot Slave study (WKSS)	biblio west kitikmeot.doc	1994 - 2001	Both	Freshwater, marine, terrestrial	Regional
Yukon State of the Environment Report	biblio yukon soe.doc	1995 - ongoing	Both	Wetland, terrestrial forest	Regional

5. NEI Indicators Inventory (Detailed Table)

	Indicators	Variables	Comments	Links
Abiotic	1. Ambient air quality: particulate matter monitoring	carbon monoxide, nitrogen oxides, ground level ozone		biblio yukon soe.doc
	2. Bering Sea: days with ice		After March 15	biblio Arctic change.doc
	3. Cesium in caribou		In muscle	biblio arctic borderlands.doc
	4. Climate change greenhouse gas emissions by sector/year;			biblio yukon soe.doc
	5. Contaminants in fish, mammals and food	Organochlorine, organohalogen, POPs, and metal contaminants		biblio arctic borderlands.doc; biblio northern contaminants.doc
	6. Contaminants in caribou			biblio BQCMB.doc
	7. Contribution of mountain and subpolar glaciers to sea level	Sea level change		biblio Arctic change.doc
	8. Ferry & ice bridge operation	Days of operation		biblio mackenzie.doc
	9. Frequency of snow cover dates			biblio Arctic change.doc
	10. Hydrologic regime	Water balance of small tundra lake		biblio canttex.doc
	11. Mercury in birds	mg/kg in egg		biblio arctic seabird.doc
	12. Mercury in marine mammals		Beluga and seal liver	biblio arctic borderlands.doc
	13. New chemical contaminants in Arctic seabirds	Bbrominated flame retardants (BFRs) chlorinated naphthalene (PCNs), chlorinated paraffins (CPs), and fluorinated sulfonic and alkanoic acids		biblio northern contaminants.doc
	14. Ocean temperatures		Summer	biblio Arctic change.doc
	15. Organochlorines in Beluga		Fat samples	biblio arctic borderlands.doc

	Indicators	Variables	Comments	Links
	16. PCBs in birds	mg/kg in egg		biblio arctic seabird.doc
	17. Permafrost: mean annual ground temperature & permafrost distribution			biblio Arctic change.doc
	18. Rivers: flooding			biblio mackenzie.doc
	19. Rivers: freeze-up & break-up dates	Dates in years		biblio BQCMB.doc; biblio yukon soe.doc
	20. Rivers: relative river discharge			biblio Arctic change.doc
	21. Roads: open period for Tundra travel			biblio Arctic change.doc
	22. Sea ice extent			biblio Arctic change.doc
	23. Seasonal characteristics identification by month	weather & temperature	qualitative	biblio hudson bay tek.doc
	24. Seasonal temperature		EC trend lines	biblio BQCMB.doc
	25. Snow cover anomalies		Eurasia	biblio Arctic change.doc
	26. Snow pack thickness	Thickness of snow pack		biblio kluane.doc
	27. Spatial patterns of contaminants in polar bears		Tissue analysis	biblio northern contaminants.doc
	28. Summer melt		Maximum amount	biblio Arctic change.doc
	29. Temperature anomaly			biblio Arctic change.doc
	30. Temporal trends of atmosphere mercury		Air samples	biblio northern contaminants.doc
	31. Time series of snow melt dates			biblio Arctic change.doc
	32. Volume changes of ice caps and glaciers			biblio Arctic change.doc
	33. Water quality	Sewage effluent		biblio mackenzie.doc
	34. Water quality	% frequency of exceeded guidelines		biblio mackenzie.doc
	35. Water quality	Arsenic and zinc concentrations		biblio mackenzie.doc

	Indicators	Variables	Comments	Links
	36. Water quality	Turbidity: Cloudiness and sediment; particle size		biblio mackenzie.doc
	37. Water quality index (Alberta)			biblio mackenzie.doc
	38. Water quality	Absorbable organic halides		biblio mackenzie.doc
	39. Water quality	Dissolved oxygen	Minimum wintertime levels	biblio mackenzie.doc
	40. Water quality	Dissolved phosphorous		biblio mackenzie.doc
	41. Water quality	Fish consumption advisories		biblio mackenzie.doc
	42. Water quality	Organic matter in pulp mill effluents		biblio mackenzie.doc
	43. Water quantity	Lake & river water level		biblio mackenzie.doc
	44. Water quantity	Snowpack accumulation		biblio mackenzie.doc
	45. Water quantity: annual flow	Average; peak; spring freshets		biblio mackenzie.doc
	46. Weather	Temperature, precipitation, snow cover		biblio hudson bay tek.doc; biblio kluane.doc; biblio parks west arctic.doc
Biotic	1. Fish species observation			biblio rat river.doc
	2. Mammal species observation			biblio aklavik tek.doc; biblio west kitikmeot.doc
	3. Bird species observation			biblio rat river.doc; biblio aklavik tek.doc; biblio west kitikmeot.doc
	4. Amphibian & fish species	Occurance	Search and angler sampling	biblio Hyland River.doc
	5. Animal checklist survey	Birds, mammals		biblio canttex.doc biblio west kitikmeot.doc
	6. Animal monitoring		Nesting of other bird species,	biblio canttex.doc

	Indicators	Variables	Comments	Links
			monitoring of lemmings & foxes	
	7. Animal population & monitoring		Different species	biblio canttex.doc
	8. Aquatic & riparian-dependent wildlife species at risk	# of species		biblio mackenzie.doc
	9. Arctic cod production & biomass			biblio Arctic change.doc
	10. Arctic ground squirrels	Population dynamics; habitat use; social behavior		biblio kluane alpine.doc
	11. Beluga abundance		Estimated #/year	biblio arctic borderlands.doc; biblio hudson bay tek.doc
	12. Berry production	Soapberry, ground berries		biblio kluane.doc
	13. Biodiversity	Plant biodiversity		
	14.	Comparison of the biodiversity of alpine communities of different glacial histories	Biodiversity (alpine) in the southwest Yukon	biblio kluane alpine.doc
	15. Biomass of herbivores using faecal-pellet counts	Muskoxen, caribou, arctic hare, geese & ptarmigan		Biblio Tundra exped.doc
	16. Bird arrival	Date of first sighting		biblio canttex.doc
	17. Bird phenology	Arrival and nesting dates		biblio canttex.doc
	18. Bird species richness		Survey	biblio Hyland River.doc; biblio parks west arctic.doc
	19. Birds: population			biblio arctic borderlands.doc; biblio yukon soe.doc
	20. Bowhead abundance		Estimated #/year	biblio Inuit bowhead.doc; biblio arctic borderlands.doc
	21. Breeding bird surveys & point counts	Passerine and landbirds		biblio kluane.doc
	22. Caribou birth rate		Radio-collared	biblio arctic borderlands.doc

	Indicators	Variables	Comments	Links
	23. Caribou calving ground location		Food value & protein content of plants eaten by caribou	biblio west kitikmeot.doc
	24. Caribou calving habitat use		Radio-collared + computer programmed	biblio arctic borderlands.doc
	25. Caribou herd size		Aircraft visual; aerial photos; estimates	biblio BQCMB.doc
	26. Caribou water & ice crossings		Personal observation	biblio BQCMB.doc
	27. Caribou behavior around mines		Remote cameras	biblio west kitikmeot.doc
	28. Caribou: population, range (distribution); forage calving grounds			biblio yukon soe.doc; biblio arctic borderlands.doc; biblio parks west arctic.doc
	29. Caribou: porcupine caribou herd size	Total count on calving grounds	Airplane photos	biblio Arctic change.doc
	30. Caribou: seasonal movements		Collared; satellite transmitters	biblio west kitikmeot.doc
	31. Caribou: TEK on migration & state of caribou habitat		Remote cameras	biblio west kitikmeot.doc
	32. Caterpillar monitoring	Density and age class off caterpillar		biblio canttex.doc
	33. Coastal erosion	Cliff and beach topography; sediment grain size is measured using settlings; sea temperatures and storm surge monitoring		biblio parks west arctic.doc

	Indicators	Variables	Comments	Links
	34. Collared Pikas	Population dynamics; genetics, social behaviour		biblio kluane alpine.doc
	35. Dall's Sheep	Habitat change; horn growth		biblio kluane alpine.doc
	36. Ducks: ring neck duck populations		Aerial survey	biblio Arctic change.doc
	37. Early plant growth		In caribou calving areas	biblio wapusk.doc
	38. Fish Harvest			biblio arctic borderlands.doc
	39. Fish populations		Qualitative	biblio mackenzie.doc
	40. Forests	Forest fires statistics, infestation, species inventory		biblio yukon soe.doc
	41. Furbearing mammals: population			biblio yukon soe.doc
	42. Goose population ecology: nesting and banding	Nest distribution		biblio canttex.doc
	43. Grizzly bear population ecology		Satellite transmitter collars	biblio west kitikmeot.doc
	44. Grizzly bears: population			biblio yukon soe.doc
	45. Herd range & movements		Radio collar monitoring	biblio BQCMB.doc
	46. Lemming & vole abundance			Biblio Tundra exped.doc
	47. Lemming population			biblio canttex.doc
	48. Lemmings monitoring: population change	# of Winter nests		biblio parks west arctic.doc
	49. Locations of calving caribou		Information varies	biblio BQCMB.doc
	50. Mammal species		Presence recorded	biblio rat river.doc biblio TEK fishery.doc biblio Hyland River.doc

	Indicators	Variables	Comments	Links
	51. Moose population		Survey	biblio yukon soe.doc; biblio parks west arctic.doc
	52. Mortality of moss	Drought induced degeneration		biblio moss mortality.doc
	53. Mushrooms: standing crop			biblio kluane.doc
	54. Number of peregrine falcons	# of pairs and # of pairs with young per year		biblio yukon soe.doc
	55. Owl census	Annual population		biblio kluane.doc
	56. Pika & marmot abundance & population dynamics			biblio kluane alpine.doc; biblio kluane alpine.doc
	57. Pingo monitoring	Ecological change		biblio parks west arctic.doc
	58. Plant communities	Relative amount of ground cover		biblio wapusk.doc
	59. Plant communities & species composition		Field stop observations	biblio Hyland River.doc
	60. Plant measurements	# count in July	20 plots	biblio canttex.doc
	61. Plant phenology		Different species	biblio canttex.doc
	62. Plant productivity changes		Satellite images	biblio parks west arctic.doc
	63. Polar bear abundance		Estimated	biblio arctic borderlands.doc
	64. Porcupine Caribou herd birth rate			biblio Arctic change.doc
	65. Predator abundance	Index of relative abundance		biblio kluane.doc
	66. Predator species census	foxes, raven, glaucous gull, rough-legged hawk, long-tailed; jaeger, parasitic jaeger, ermine, snowy owl, peregrine falcon, gyrfalcom		Biblio Tundra exped.doc
	67. Raptor survey	# of peregrine falcons and other species of raptors		biblio parks west arctic.doc

	Indicators	Variables	Comments	Links
		breeding		
	68. Red squirrel & ground squirrel ecology & population dynamics	Population density	Estimates	biblio kluane.doc
	69. Ringed seal abundance		Aerial survey	biblio arctic borderlands.doc
	70. Ringed seal productivity	Pups in harvest		biblio arctic borderlands.doc
	71. Salmon	Number arrive to spawn		biblio arctic borderlands.doc
	72. Salmon run size and returns for spawning	Chinook, chum and coho		biblio yukon soe.doc
	73. Seal body condition (fatness)		Ringed seals	biblio Holman seals.doc
	74. Seal reproduction	Ovulation rate and percent of pups in the harvest		biblio Holman seals.doc
	75. Shrub browse	Rate of loss of tagged twigs of willow and birch		biblio kluane.doc
	76. Shrub growth	Annual production index	tagged willow & birch shrubs	biblio kluane.doc
	77. Small mammal abundance		Estimates from live trapping	biblio kluane.doc
	78. Small mammal ecology: population dynamics			biblio canttex.doc
	79. Snowshoe hare abundance	Relative density	estimates	biblio kluane.doc
	80. Species at risk under COSEWIC			biblio yukon soe.doc
	81. Spring classification surveys	Calf/cow ratio		biblio BQCMB.doc
	82. Standing crop of vascular plant		corrected for phenology	Biblio Tundra exped.doc
	83. Stocks of northeast arctic capelin and Norwegian spring-spawning herring		Biomass	biblio Arctic change.doc
	84. Thinhorn sheep: population	no lambs per 100 nursery sheep		biblio yukon soe.doc
	85. Tree health	Survival of spruce seedlings and saplings		biblio wapusk.doc

	Indicators	Variables	Comments	Links
	86. Tundra area based on NDVI and Koppen Classification			biblio Arctic change.doc
	87. Vegetation composition		Visual assessment	biblio canttex.doc
	88. Vegetation composition: cover & biomass data			biblio canttex.doc
	89. Vegetation structure	Abundance and composition along snow melt gradient		biblio canttex.doc
	90. Vegetation: density of reproductive structures	# count in July		biblio canttex.doc
	91. Vegetation: dynamics	Primary productivity	NDVI measurements	biblio kluane.doc
	92. Vegetation: herbivory effects on alpine plants		Effects on species composition, productivity and demography	biblio canttex.doc
	93. Vegetation: phenology			biblio canttex.doc
	94. Vegetation: plant production	In grazed and non-grazed wetlands		biblio canttex.doc
	95. Vegetation: Present day natural vegetation		floristic surveys; Arctic	biblio Arctic change.doc
	96. Waterfowl ecology		Population ecology	biblio canttex.doc
	97. Waterfowl: population trend	Population size	Estimates	biblio mackenzie.doc
	98. Waterfowls populations	Number of scoters & ducks		biblio arctic borderlands.doc
	99. Wetland inventory	surveys		biblio yukon soe.doc
	100. Wetland monitoring		ITEX site	biblio canttex.doc
	101. White spruce cone	Annual rates		biblio kluane.doc

	Indicators	Variables	Comments	Links
	production			
	102. Wolf habitat use for denning		Collared	biblio west kitikmeot.doc
	103. Wolverine ecology	Range and physical characteristics	Collared	biblio west kitikmeot.doc
Climate	1. Active layer depth	2 thaw transects		biblio canttex.doc; biblio yukon soe.doc; biblio parks west arctic.doc
	2. Arctic oscillation			biblio Arctic change.doc
	3. Clouds	Averaged fraction over sea	Spring time series	biblio Arctic change.doc
	4. Community-level climate change		Qualitative	biblio Arctic change.doc
	5. Delayed snowmelt		Shoveling experiments	biblio kluane alpine.doc
	6. Glacier			biblio canttex.doc
	7. Global city temperatures	# of days with cold N. wind		biblio Arctic change.doc
	8. Global ocean overturning	Pathways of transformation		biblio Arctic change.doc
	9. Ground temperature			biblio Arctic change.doc
	10. Marine access		Arctic sea ice extent; ice breaker access	biblio Arctic change.doc
	11. Snow phenology	2 snowmelt transects		biblio canttex.doc
	12. Soil temperatures at snow fence			biblio yukon soe.doc; biblio canttex.doc;
	13. Spring snowmelt			biblio hudson bay tek.doc biblio kluane alpine.doc
	14. Stratospheric air temperatures	Anomalies in March		biblio Arctic change.doc
	15. Surface temperatures		Weather stations	biblio Arctic change.doc
	16. Temperatures	16 variables	Data loggers	biblio Arctic change.doc

	Indicators	Variables	Comments	Links
			record above ground & below temperatures & relative humidity in & out of OTCs	biblio yukon soe.doc biblio hudson bay tek.doc
Traditional Knowledge	1. Bowheads observations	Abundance, migration, group size, calves occurrence, feeding ecology, aggression, age & size	Qualitative; Inuit observation	biblio Inuit bowhead.doc
	2. Caribou physical condition		Hunters survey	biblio BQCMB.doc
	3. Changes and differences in fish species		qualitative	biblio TEK fishery.doc
	4. Fishery runs		qualitative	biblio TEK fishery.doc
	5. Observation of aquatic species & habitat		qualitative	biblio mackenzie.doc
	6. Physical changes along coast		qualitative	biblio TEK fishery.doc
	7. Polar bear movements & abundance		qualitative	biblio hudson bay tek.doc
	8. Snow & Canada goose migrations & abundance		qualitative	biblio hudson bay tek.doc
	9. Sturgeon abundance		qualitative	biblio hudson bay tek.doc

6. Bibliographic Data of Indicator Initiatives

Title of Indicator Initiative / Program
Aklavik Inuvialuit describe the status of certain birds & animals on the Yukon North Slope, March 2003.

Initiative / Program objectives
This report summarizes information about how certain animals and birds are doing on the Yukon North Slope and in the western Mackenzie Delta. This information comes from ten interviews and a public meeting conducted in Aklavik, NWT, in March and April, 2003.
The work was done for four reasons. First, there was a widely shared interest by the Aklavik Hunters and Trappers Committee (AHTC) and the agencies represented on the Wildlife Management Advisory Council (North Slope) in honouring the knowledge and experience of the many skilled hunters and trappers in Aklavik with a report that described not only the animals, but how they are known. The second reason was to check how birds and animals were doing and to see if any of them needed management attention. The third was to provide a current source of local interview information that could be used to update and expand the Yukon North Slope Wildlife Population Status Reports (a component of the Yukon North Slope Wildlife Conservation and Management Plan). The new species at risk legislation requires aboriginal traditional and community knowledge to be used in species assessment, so this work may help the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to complete their assessments.
Finally, there was a need to provide an example of an inexpensive way to do and write up a regional, multi-species assessment based on local knowledge. [Retrieved 1 February 1, 2005 from the World Wide Web: http://www.taiga.net/wmac/aklavikreport/introduction.html]

Year(s) of Initiative / Program: 2003

Indicator development process used: local, traditional knowledge

Ecosystem type: terrestrial, coastal

Indicators identified

Indicator	Years of data	Location of monitoring	Measurement
Bird status	2003	Yukon North slope	Qualitative – description of various species, their numbers, condition, range and habitat
Animal status	2003	Yukon North slope	Qualitative – description of various species, their numbers, condition, range and habitat

Note: species described are: American Robin Kuyapigaqturutin; Arctic Fox Tigiganniaq; Arctic Ground Squirrel Sikrik; Brant Nirglingaq; Common Eider Qauraviq; Greater White-fronted Goose Nirliq; Grizzly Bear Aklaq; Lemming Qilakmiutaq; Long-tailed Duck Ahaliq; Moose Tuttuvak; Mouse and Vole Avingnaq; Red Fox Kayuqtuq; Red-necked Phalarope Livalivauraq; Shrew Ugruknaq; Snow Goose Kanuq; Snowy Owl Ukpik; Varying Hare Ukalliq; White-winged and Surf Scoters Aviluqtuq; Willow Ptarmigan Qargiq; Wolf Amaguq; Wolverine Qavvik.

Geographic scope of indicators: Yukon North Slope

Ecozone(s): southern Arctic, taiga cordillera (?)

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Yukon Territory; Inuvialuit Settlement Region

Measurement framework adopted

Information available as: qualitative. Questions look at changes and concerns about numbers, condition, range and habitat of certain animals on the North Slope.

Sources of Information

a.) Reports
Wildlife Management Advisory Council (North Slope) and the Aklavik Hunters and Trappers Committee. *Aklavik Inuvialuit describe the status of certain birds & animals on the Yukon North Slope, March 2003.* Final report. Wildlife Management Advisory Council (North Slope), Whitehorse, Yukon.
http://www.taiga.net/wmac/aklavikreport/akreport.pdf

b.) Websites: http://www.taiga.net/wmac/aklavikreport/index.html

c.) Organization(s) responsible and Contact person(s)
Wildlife Management Advisory Council (North Slope)
P.O. Box 31539, Whitehorse, Y.T. Y1A 6K8 Canada
Telephone: (867) 633-5476 Fax: (867) 633-6900
E-mail: wmacns@web.ca www.taiga.net/wmac

Title of Indicator Initiative / Program:
Arctic Borderlands Ecological Knowledge Co-op Indicators

Initiative / Program objectives:
A meeting in Dawson City in the fall of 1994 brought together interested parties to start an ecological monitoring program for the Northern Yukon.. Participants identified the three main issues that should be the focus of ecological monitoring: climate change contaminants and regional development. Participants also decided that an important part of the program should be to bring together science and local and traditional knowledge. The objective of the indicator initiative is to track and communicate indicators of ecosystem change. [website]

Year(s) of Initiative / Program: 1994 – ongoing

Indicator development process used: local, traditional knowledge and scientific knowledge & methods. Community based monitoring takes place in Arctic Village, Old Crow, Aklavik, Fort McPherson, Tsiigehtchic, Inuvik and Tuktoyaktuk.

Ecosystem type(s): coastal, northern river basins, ocean and terrestrial

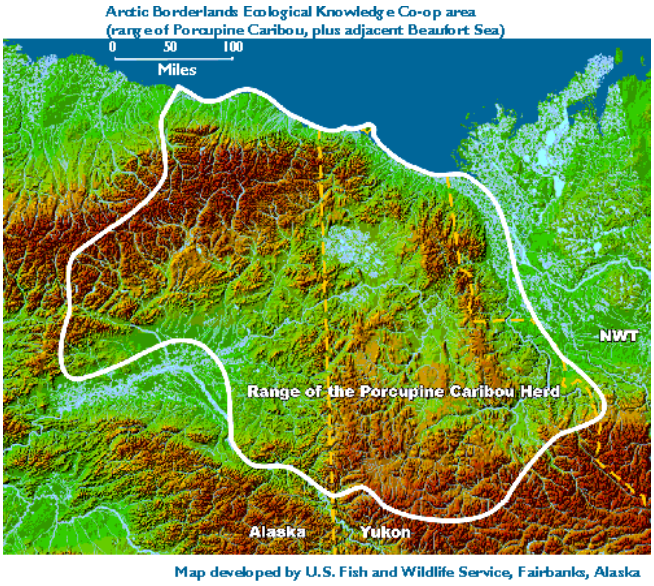
Indicators identified

	Indicator	**Years of data**	**Location of monitoring**	**Measurement**
Biotic	Early plant growth in caribou calving areas	1985 - 2001	Porcupine caribou herd calving grounds	Green biomass measured by NDVI on June 21
	Monitoring of plant communities in Old Crow	Data collected in 1997	Old Crow	graphs showing the relative amount of ground cover of different plants that are present in the three plant communities that are being monitored near Old Crow
	Waterfowl populations on Old Crow Flats	1955-2000	Old Crow Flats	Number of scoters & ducks counted by doing aerial surveys at Old Crow flats each year
	Number of Peregrine falcons in Northern Yukon	1975-1999	Northern Yukon	No. of pairs with young per year and total pairs observed per year
	Peel River Fish Harvest	1996-1998	Fort McPherson, NWT,	reported fish harvest for Fort McPherson, NWT, recorded for 1996-1998 by the Gwich'in Harvest Survey.
	Salmon in the Porcupine River system	1971-2004	Fishing Branch River (tributary to the Porcupine River)	number of chum salmon which arrive at the Fishing Branch River (tributary to the Porcupine River) to spawn each year. (mainly fish wier counts)
	Bowhead abundance	1978 - 2001	Bering/Chukchi/Beaufort Seas	Estimated number per year
	Beluga abundance	1990 1996	Beaufort Sea	Estimated number per year
	Ringed seal abundance	1982-1986	Beaufort Sea	Seals per 100 sq. km each year based on aerial survey flights in August and September

	Indicator	Years of data	Location of monitoring	Measurement
	Ringed seal productivity	1970 - 1995	Holman Island / Beaufort Sea	Pups in harvest each year
	Polar bear abundance	1990 - 1996	Beaufort Sea	Estimated numbers per year
	Caribou birth rate	1983 - 2003	Porcupine caribou herd	Calves per 100 cows per year. Information is gathered from radio-collared caribou cows.
	Caribou population: herd size	1971 - 2001	Porcupine caribou herd	total counts of the caribou on their calving grounds. The census is done by taking photos from an airplane and counting the caribou
	Caribou calving habitat use	1983 - 2001	Porcupine caribou hers	A computer program was used to calculate each year's calving range and concentrated calving areas based on the calving locations of radio-collared cows
	Moose population	1989 & 2000	North Richardson Mountains	Number of moose and % calves for each of the two years when survey was done
Abiotic	Organochlorines in Beluga	1982 – 1996	Mackenzie Delta	analysis of fat samples from 5 to 35 beluga collected in the Mackenzie Delta showing contaminant concentration in fat (parts per billion)
	Mercury in Marine Mammals	Ringed seals: 1972 – 73 & 1987-93 Beluga: 1981 – 84 & 1993 – 94	Beaufort Sea	levels of total mercury in liver of beluga and ringed seal taken from the Beaufort Sea area. Measured as parts per million wet weight
	Cesium in Caribou	1964, 1987, 1995	Barrow, Alaska, Porcupine & Bluenose caribou herds	cesium-137 levels in the muscle of caribou from the Western Arctic measured as Bq / kg ww
Human use	Airplane flights: Aklavik	1979 - 2003	Aklavik, Fort McPherson, Tuktoyaktuk, Old Crow	*total number* of aircraft movements per year
	Community populations: American –	1960 - 2000	Arctic Village, Fort Yukon, Kaktovik, Venetie	Number per year per community (census data is used)
	Community populations: Canadian	1966 - 2001	Aklavik, Fort McPherson, Inuvik, Tsiigehtchic, Tuktoyaktuk, Old Crow	Number per year per community (census data is used)
	Yukon Development permits: water licences	1994 - 2004	North Yukon	water licences and *Notification of water use without a licence*.per year

	Indicator	Years of data	Location of monitoring	Measurement
	Yukon Development permits: CEAA screenings	1994 - 2004	North Yukon	Number of screenings per year
	Furs harvested	1986 - 2003	Yukon Territory	average price for furs sold at auction in southern Canada / year
	Park Visitors	Herschel Island & Arctic Refuge: 1993 – 2003 Ivvavik & Vantut: 1989 - 2003		Number of visitors / year (mainly estimated from guest book signatures)
	Seismic Lines and Roads	No date	Yukon Territoriy	Map
	Oil and Gas Land Dispositions, Northern Yukon	1987 - 2003	Northern Yukon	amount of land the Yukon government has assigned to companies granting them subsurface rights to explore for oil or gas / year.
	Dempster Highway Traffic, NWT	1993 - 2003	just north of the NWT/YT border.	Average vehicles per day per year
	Dempster Highway Traffic, Yukon	1973 - 2003	southern end of the Dempster Hwy near Tombstone.	Vehicles per day per year

Geographic scope of indicators: Range of the Porcupine Caribou Herd



(http://www.taiga.net/coop/reference/maps/topomap.gif)

Ecozone(s): taiga cordillera

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Northern Yukon, Northwest Territories, and Alaska

Measurement framework adopted: n/a

Information available as: trend information

Sources of Information

a.)Reports:
The following html reports are available at the website under 'Indicator Assessments 'at:
http://www.taiga.net/coop/reference/indicator_assessments.html

Abundance and distribution of coastal birds
Broad Patterns of Annual Movements of Caribou
Fat Levels of Polar Bears
Permafrost and Soil Temperatures
Plant Indicators of Climate Change
Tree Ring Analysis for Past Climate Change Information
Tree Ring Analysis for Metals Levels

b.)Websites: http://www.taiga.net/coop/index.html

Artic Borderlands Ecological Knowledge Co-op. *Indicators*. Retrieved on 17 December 2004 from the World Wide Web: http://www.taiga.net/coop/indics/index.html

Summary: The Knowledge Co-op has a list of about 75 indicators that participants are interested in monitoring. Developed data sets, with explanations, are in place for approximately 40 indicators. Potential indicators were identified at the First Annual Gathering and are reviewed each year [website]

c.) Organization(s) responsible and Contact person(s)
Arctic Borderlands Ecological Knowledge Society
91780 Alaska Highway
Whitehorse, Yukon
Canada Y1A 5B7
Telephone: 1-867-667-3949
Email: borderlands@taiga.net
President: Randall Tetlichi (Old Crow)

Title of Indicator Initiative / Program
Arctic Change: a near real-time Artic change indicator website

Initiative / Program objectives
The objective of this website is to present recent indicators that describe the present state of the Arctic climate and ecosystem in an accessible, understandable, and credible historical context. [Retrieved 1 February 2, 2005 from the World Wide Web: http://www.arctic.noaa.gov/detect/index.shtml

Year(s) of Initiative / Program:

Indicator development process used: scientific knowledge & methods

Ecosystem type: coastal, ocean, terrestrial

Indicators identified

	Indicator	**Years of data**	**Location of monitoring**	**Measurement**
Biotic	Stocks of northeast Arctic capelin and Norwegian spring-spawning herring.	1950 - 2000	NE Arctic	Biomass each year
	Greenland crustaceans/shrimp	1961 - 2001	Greenland	Thousands of tonnes each year
	Bering Sea Pollock.	1960 - 2000	Bering Sea	Recruits (millions of fish each year)
	Seal: Northern fur seal Callorhinus ursinus pups born on St. Paul	1975 - 2004	St. Paul, Bering Sea	Pups born each year
	Arctic cod production & biomass	1960 - 2000	Barents Sea	production or recruitment of cod (millions each year)
	Ducks: Ring neck duck populations on Old Crow Flats	1955 - 2000	Old Crow flats	aerial surveys on the Old Crow Flats
	Caribou: Porcupine Caribou herd size	1971 - 2001	Porcupine caribou herd	total counts of the caribou on their calving grounds. The census is done by taking photos from an airplane and counting the caribou. *
	Porcupine Caribou herd birth rate	1983 - 2003	Porcupine caribou herd	number of calves born for every 100 cows during calving period
	Tundra area based on NDVI and Koppen Classification	1982 - 2000	Circumpolar Arctic	

	Indicator	Years of data	Location of monitoring	Measurement
	Vegetation: Present day natural vegetation of the Arctic and neighboring regions from floristic surveys.	n/a	Circumpolar Arctic	
Abiotic	Climate: Arctic oscillation	1950 - 2005	Circumpolar Arctic	Winter AO index
	Climate: surface temperatures	1950 - 2000	Cities of: Tromso, Dikson, Tiksi, Barrow, Resolute, Egedesminde	temperature changes since 1950 at seven Arctic city weather stations for winter (December-January) and spring (April).
	Climate: stratospheric air temperatures	1983 - 2004	Circumpolar Arctic	stratospheric temperature anomalies in March for different years
	Climate: clouds	1980 - 2000	Circumpolar Arctic	Time series of seasonally averaged cloud fraction over the arctic seas in spring (March, April, May)
	Climate: global city temperatures	1960 - 2000	Cites of: Minneapolis, Tokyo, Moscow	number of days in each winter in which there are cold winds from the north.
	Climate: global ocean overturning	n/a	Atlantic Thermohaline circulation	pathways associated with the transformation of warm subtropical waters into colder subpolar and polar waters in the northern North Atlantic.
	Roads: open period for Tundra travel	1970 - 2000	Alaska north slope	Time period when roads are open for travel
	Permafrost: mean annual ground temperature & permafrost distribution	1930 - 2003	Fairbanks, Alaska (mean annual ground temperature);	

	Indicator	Years of data	Location of monitoring	Measurement
			Northern Hemisphere (permafrost distribution)	
	Rivers: Annual runoff of Lena, Ob and Yenisey Rivers	1930 - 2000	Lena, Ob and Yenisey Rivers	
	Rivers: relative river discharge	n/a	Circumpolar Arctic	discharge in cubic kilometers per year
	Southeast Bering Sea summer ocean temperatures	1995 - 2004	Bering Sea	
	Bering Sea:Number of days with ice cover after March 15 in the area 56-58°N, 163-165°W	1973 - 2004	Bering Sea	
	Annual Temperature anomaly (from 1961-1990 mean) for Kola and Station 27. (Kola Section off northwestern Russia, 0-200 m mean) and the Labrador Sea (Station 27 on the western Grand Bank off eastern Canada, near bottom at 175 m).	1961 - 1990	Labrador Sea; Annual Temperature anomaly (from 1961-1990 mean) for Kola and Station 27. (Kola Section off northwestern Russia, 0-200 m mean) and the Labrador Sea (Station 27 on the western Grand Bank off eastern Canada, near bottom at 175 m).	Temperatures are expressed as anomalies, i.e., differences from their 1961-1990 means
	Sea ice extent trend for the Northern Hemisphere	1975 - 2005	Northern Hemisphere	
	Ice-surface melting onset	2002 - 2004 summers	North Pole	Date of onset (observed via web cameras along with automatic station & instrumentation
	Accumulated annual volume changes of ice caps and glaciers in the American Arctic (red), the Russian Arctic (green), the Eurasian Arctic (blue), and the entire Arctic (purple).	1960 - 2000	Circumpolar Arctic	
	Contribution of mountain and subpolar glaciers to sea level	1960 -- 2000	Circumpolar Arctic	Sea level change mm / year

	Indicator	Years of data	Location of monitoring	Measurement
	Maximum summer melt extent over Greenland and examples of the melt extent during 1992 and 2002 .	1979 - 2002	Greenland	
	Eurasian Snow Cover Anomalies	1966 - 2004		
	North American (except Greenland) Snow Cover Anomalies.	1966 - 2004		
	Time series of snow melt dates (date when snow disappeared)	1940 - ongoing	NOAA/CMDL Barrow Observatory.	
	Frequency of snow cover on the land areas of the Northern Hemisphere during February and May		Circumpolar Arctic	
	Climate change: community-level indicators	qualitative	Shishmaref, North Alaska; Sachs Harbour;	qualitative
	Marine access		Arctic Ocean including Canadian Arctic (Northwest Passage)	Arctic sea ice extent; ice breaker access

Geographic scope of indicators

Ecozone(s):

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: circumpolar countries:

Map of the Arctic region.
From the University of Texas Perry-Castaneda Library map collection.
[Retrieved 2 February 2005 from the World Wide Web: http://www.arctic.noaa.gov/detect/overview.shtml]

Measurement framework adopted

Data sources: (e.g. scientific, statistical, traditional knowledge, etc.)

Information available as: trend information

Sources of Information

a.) Reports
none

b.) Websites
http://www.arctic.noaa.gov/detect/index.shtml

c.) Organization(s) responsible and Contact person(s)
Dr. John Calder, Director
Arctic Research Office
NOAA
Note: couldn't find contacts at website

Title of Indicator Initiative / Program
ArcticNet Theme 2/Northern RiSCC.
Coastal terrestrial observatories in the eastern Canadian Arctic

Year(s) of Initiative / Program: ArcticNet is a network studying climate, terrestrial and freshwater ecosystems, human health and coastal communities in the changing Arctic.
April 2004 to 2010 with possibility to extend to 2017
Within ArcticNet the indicators have been collected since April 2004, however, many components of Northern RiSCC have been existing several years before the initiation of ArcticNet.

Indicator development process used: local, traditional knowledge and scientific knowledge & methods
Indicators (key ecosystem state and trend indices) have been selected based on the information gathered from previous intensive field studies and on the needs of northerners

Ecosystem type: terrestrial ecosystems including lakes and ponds

Indicators identified:
List is huge including indicators from natural science, health science and social science focused studies. [Note: list of indicators not supplied by ArcticNet contact]

Geographic scope of the indicator(s): (incl. number and type of location(s), e.g. coastal, oceanic, etc.)
The geographic focus of these terrestrial observatories is on the coastal lands and freshwaters in a sector that crosses the boreal, subarctic and arctic ecoclimatic provinces, with vegetation zones ranging from forest to shrub tundra to high arctic polar desert. It spans over 30 degrees of latitude (53 to 83 ^{o}N) and a broad range of temperature regimes, from a mean annual temperature of –2 ^{o}C at the southern end (James Bay) to –20 ^{o}C at Ward Hunt Island, in Quttinirpaaq National Park, northern Ellesmere. Land-based observations will be coupled with measurements obtained using the research icebreaker CCGS Amundsen as a moving field station throughout the duration of Arctic Net (2004-2010).

The environmental observations of Theme 2/Northern RiSCC will be closely cross-linked with other existing initiatives. For example, they will make full use of the new climate station network called SILA ('climate' in Inuktitut) that extends from near James Bay (Radisson) to the Ward Hunt-Ellesmere Island region, and operated by Centre d'études nordiques. This terrestrial network also integrates closely via several proposed IPY project.

Measurement framework adopted: (e.g. Pressure-State-Response, etc.)
In general the observations are made in two separate but highly linked levels, the environmental conditions in the Arctic in the past are obtained from traditional knowledge of the northerners and using multi-proxy paleoecological proxies from lake sediments, ice cores, tree and shrub annual growth rings. Present day observations are based on direct weather and environmental measurements as well as on the state of biological populations. Together they form a dataset that will contribute to the monitoring of the present transformation of the North and bases for any mitigation efforts and policy developments on land.

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries::
Nunavik, Nunavut.

Data sources: Scientific and traditional knowledge.

Information available as raw data or already synthesized into trend information:
At least the climate station measurements.

Lessons learned: (e.g. reliability of indicator data; do the indicators support program objectives, do they help the analysis of data or trend analysis, are they used in synthesis reports, are they also communication tools, etc.)

Source of Information

a) Reports

b) Websites:
ArcticNet website
http://www.arcticnet-ulaval.ca/

c) Organization(s) responsible and Contact person(s): (Name(s), address, phone number, e-mail address)

Executive Director- ArcticNet
Martin Fortier, ArcticNet, Department of Biology, Université Laval, 418-656-5233,
martin.fortier@arcticnet.ulaval.ca

Theme 2 Coordinator
Milla Rautio D Department of Biology, Université Laval, 418-656-7106, milla.rautio@bio.ulaval.ca

Title of Indicator Initiative / Program
Climate change impacts on tundra ecosystems (CANTTEXT)

Initiative / Program objectives
To increase our capability to detect and predict large-scale tundra and taiga ecosystem response to climate change. The network's objectives are to develop partnerships among researchers in different political jurisdictions and geographical locations, and to build a monitoring network based on common protocols so that data can be exchanged and synthesized across multiple sites. [Retrieved on January 31, 2005 from the World Wide Web: http://www.taiga.net/canttex/index.html]
The network will build on studies and methods of the International Tundra Experiment (ITEX).

Year(s) of Initiative / Program:
ITEX was initiated in 1990 and continued as CANTTEX in 2000 (p2). The first monitoring site opened in 1992.

Indicator development process used: Scientific knowledge & methods

Ecosystem type: Terrestrial

Indicators identified

	Indicator	**Years of data**	**Location of monitoring**	**Measurement**
Biotic	Vegetation composition: cover & biomass data	1992 - present	Alexandria Fiord Lowland	Cover & biomass data from all
	Vegetation: phenology	1992 - present	Alexandria Fiord Lowland	Phenological observations from all experimental plots
	Bird arrival	1980-1984, 1992 - present	Alexandria Fiord Lowland	Date of first sightings and nests
	Woolly-bear caterpillar monitoring	1993 - present	Alexandria Fiord Lowland	Observing density and age-class of caterpillars along tansects
	Goose population ecology: nesting and banding	1995 - present	Bylot Island	Goose nest distribution & nesting activity Goose survey & banding
	Animal monitoring	1995 - present	Bylot Island	Nesting of other bird species, monitoring of lemmings & foxes
	Vegetation: plant production	1995 - present	Bylot Island	Plant production in grazed & non-grazed wetlands; plant production in long-term enclosures
	Wetland monitoring (ITEX site)	1995 - present	Bylot Island	Monitoring of an ITEX site in wetlands
	Tundra (mesic) monitoring (ITEX site)	1998 - present	Bylot Island	Monitoring of an ITEX site in mesic tundra
	Plant phenology	1990 - 1993	Sverdrup Pass	Papaver radicatum
	Vegetation composition	1986	Sverdrup Pass	Visual assessment from quadrants
	Effects of grazing by muskoxen	1986 - 1990	Sverdrup Pass	Observations & clipping experiments Plant demography
	Vegetation: plant phenology	1994 - present	Tanquary Fiord	2 species
	Vegetation: plant phenology	1992 - present	Baker Lake	3 species monitored in controls in and out of open top chambers In the snowdrift zone
	Vegation structure	1992 - present	Baker Lake	Abundance and composition along snow melt gradient

	Indicator	Years of data	Location of monitoring	Measurement
	Vegetation: plant phenology	1995 - present	Churchill area	3 species monitored
	Vegetation composition	1999 - present	Daring Lake	Cover data from OTCs
	Vegetation: plant phenology	1996 - present	Daring Lake	8 species
	Animal population & monitoring	1995 - present	Daring Lake	Grizzly bear; wolverine; wolf; small mammals; Arctic hare; raptors; caribou
	Vegetation: plant community monitoring	1999 - present	Hershel Island	5 long-term plant community monitoring plots
	Vegetation: plant phenology	1999 - present	Hershel Island	Phenological observations for three species
	Vegetation	1997 - present	Old Crow	Six long-term vegetation monitoring plots in 3 community types
	Bird phenology	n/a	Walker Bay	Arrival and nesting dates of bird species
	Waterfowl ecology	1987 - present	Walker Bay	Population ecology study on geese and sandhill cranes
	Lemming population (small mammal study)	1994 - 1997	Walker Bay	Lemming population
	Small mammal ecology: population dynamics	n/a	Kluane Lake	Population dynamics of collared pikas, Arctic ground squirrels and hoary marmots
	Vegetation: herbivory effects & characteristics alpine plants	n/a	Kluane Lake	Effects of herbivory on species composition, productivity and demography of alpine meadows Chemical & nutritional characteristics of alpine plants
	Vegetation: composition & phenology	2001 - present	Mealey Mountains	Composition Phenology of Salix and Diapensia
	Vegetation composition	1998	Wolf Creek	Cover & biomass data from OTCs & control plots
	Vegetation: density of reproductive structures	1998 - present	Wolf Creek	# of reproductive structures by species is counted every July in 1m X 1m quadrant
	Plant measurements	1999 - present	Wolf Creek	Measurement sof dryas octopetala, polygonum viviparum, Salix arctica, and Lupinus aracticus in all 20 plots are taken every July
Abiotic	Climate	1980 - 2001	Alexandria Fiord Lowland	1 climate station 2 autostations, 16 variables Temperatures In & out of open top chambers
	Active layer depth	1992 – present 1996 - present	Alexandria Fiord Lowland	In open top chambers and control plots 10m X 10m active layer grid
	Galcier retreat	1980-1984; 1992 - present	Alexandria Fiord Lowland	Annual measurements from stakes established I previous year

	Indicator	Years of data	Location of monitoring	Measurement
	Climate	1995 - present	Bylot Island	Maintenance of automated weather station, Monitoring of ground temperature in areas grazed & ungrazed by geese Monitoring of spring snowmelt phenology
	Climate	1988 – 1989 1989 - present	Sverdrup Pass	Polar desert climate station Meadow climate station
	Climate	1986 - present	Tanquary Fiord	Autostation recording 6 variables
	Climate	1990 - 1999	Baker Lake	Meteorological station at airport 1 autostation Temperatures in and out of open top chambers Soil temperatures at snow fence
	Active layer depth	1997 - present	Baker Lake	Four 3m deep bore holes, 100 m apart
	Climate	1999 - present	Hershel Island	Soil & air temperature
	Climate	1996 - present	Daring Lake	Autostation recording 14 variables
	Hydrologic regime	1999 - present	Daring Lake	Water balance of small tundra lake & various other
	Climate	1997 - present	Old Crow	Soil temperature monitored at taiga site
	Climate	1996 - present	Walker Bay	Autostation recording 10 variables
	Snow phenology	n/a	Walker Bay	2 snowmelt transects
	Active layer depth	n/a	Walker Bay	2 thaw transects
	Climate	n/a	Kluane Lake	autostation
	Climate	2001 - present	Mealey Mountains	Autostation
	Active layer depth	2001 - present	Mealey Mountains	n/a
	Climate	1998 – present Sept 1993 - present	Wolf Creek	Data loggers record above ground & below temperatures & relative humidity in & out of OTCs; Nearby climate station records 13 variables

Distribution and number of sample locations: Location of ecological monitoring sites: Alexandrea Fiord Lowland, Bylot Island, Sverdrup Pass, Tanquary Fiord, Baker Lake, Churchill Northern Studies Centre, Daring Lake, Hershel Island, Old Crow, Walker Bay, Kluane Park, Mealey Mountains, Wolf Creek.

Geographic scope of indicators

Ecozone(s): Arctic cordillera, Northern Arctic, Southern Arctic, Taiga cordillera, Boreal cordillera, Taiga plains, Taiga shield

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Federal Government, Yukon Territory, Nunavut, Northwest Territories, Manitoba, Labrador

Measurement framework adopted: n/a

Sources of Information

a.) Reports
Bean, **David**
Henry, **Greg H. R.**
Climate change impacts on tundra ecosystems: the CANTTEX network of ecological monitoring sites in the Canadian Arctic. [s.l.], : CANTTEX / EMAN North, 2001, 32p.
Abstract: This paper serves several purposes. It is an introduction to the CANTTEX network and shows the availability of existing data and the status of current ecological monitoring in the Canadian Arctic. A preliminary analysis of some of the many variables and methods of measurement and analysis is done to provide an indication as to which variables are sensitive to environmental changes and merit continued monitoring. This will aid the development of common monitoring protocols at CANTTEX sites. Finally, the presentation of data from the six major sites included in the analysis demonstrates the effectiveness of monitoring similar variables at many sites. However, it is clear that many more data are required to improve the inferences and predictive power that are desired in the field of climate change impacts research. In addition, it is hoped that this will encourage new researchers and agencies to implement CANTTEX monitoring programs at their research sites, expanding the geographical extent of the network.
URL: http://www.emannorth.ca/reports/EN_canttexRev02.pdf

b.) Websites: http://www.taiga.net/canttex/index.html

c.) Organization(s) responsible and Contact person(s)
Note: Can't find contacts. Verify relationships to EMAN-North.

Title of Indicator Initiative / Program
Holman Seal Monitoring Project
Annual Monitoring of Ringed Seals:
Holman, NT (1992 - ongoing) and Sachs Harbour (2004-2006)

Initiative / Program objectives
The ringed seal (*Phoca hispida*) is an important species in the Arctic marine ecosystem, being the main prey of the polar bear, and a major consumer of marine fish and invertebrates. It is important to the subsistence economies of coastal Inuvialuit communities of Holman, Sachs Harbour, Tuktoyaktuk and Paulatuk. Ringed seals are harvested for food, dog food and for pelts for handicrafts and clothing.

The seals are tied very closely to the state of the ecosystem and are dependent on the sea ice for reproduction. They are proving to be a good indicator of environmental productivity and change in the Arctic. Climate change coupled with a renewed interest by the oil and gas industry in exploration in the north, could cause or contribute to effects on the seal populations. There are gaps in our knowledge about the distribution, movements and stock structure of ringed seals in this area.

We examine seal body condition (fatness) and two parameters of seal reproduction, ovulation rate and percent pups in the harvest. These parameters were selected because (1) they varied with changes in the seal population during work in this same area in the 1970's, and (2) it was possible and practical to monitor these aspects over the long-term through a harvest-based study in the community of Holman.

Year(s) of Initiative / Program: 1971 – ongoing

Indicator development process used: local, traditional and scientific knowledge & methods

Ecosystem type: marine

Indicators identified

Indicator	Years of data	Location of monitoring	Measurement
seal body condition (fatness)	1992 – ongoing (check years…can't read date on website table)	Holman, NWT (1992 - ongoing); Sachs Harbour (2004 - 2006)	approximately 100 ringed seals are taken in the regular subsistence harvest by hunters from Holman, NT, and blubber thickness is measured
seal reproduction, ovulation rate and percent pups in the harvest	1970s 1992 - ongoing	Holman, NWT (1992 - ongoing); Sachs Harbour (2004 - 2006)	% of adult females in reproductive condition,

Geographic scope of indicators

Ecozone(s): southern Arctic

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Northwest Territories, Federal Government (DFO)

Measurement framework adopted: n/a

Information available as: trend

Sources of Information

a.) Reports

b.) Websites
Beaufort sea seals: research and monitoring
http://www.beaufortseals.com/
http://www.fjmc.ca/field_programs/Seals_02/Lois_Seals/Project%20Background.htm

c.) Organization(s) responsible and Contact person(s)

(1) Olokhaktomiut (Holman)
Hunters and Trappers Committee
Box 161
Holman, NT, Canada
X0E 0S0

(2) Paulatuk Hunters and Trappers Committee
General Delivery
Paulatuk, NT, Canada
X0E 1N0

(3) Tuktoyaktuk Hunters and Trappers Committee
Box 286
Tuktoyaktuk, NT
X0E 1C0

(4) EMC Eco Marine Corporation
Garthby Station, Quebec

(5) Dept. of Fisheries and Oceans
Stock Assessment
Yellowknife, NT

Title of Indicator Initiative / Program:
Hudson Bay Traditional Ecological Knowledge and Management Systems (TEKMS)

Initiative / Program objectives:
- share information;
- understand better the environmental changes caused by development;
- identify cumulative environmental impacts of development;
- gather baseline information to measure future impacts;
- help scientists understand environmental change and problems; and
- promote the use of traditional knowledge to conserve and manage the environment. (p4)

Year(s) of Initiative / Program: research was initiated in 1992 and completed in 1995

Indicator development process used: local, traditional. The process was community based and community controlled and coordinated from Sanikiluaq. 30 communities were invited to participate and over the course of the study 78 individuals (Elders or active hunters) from 28 communities did so. The process included two study workshops, 12 regional workshops in communities around the Bay and in April 1994, a workshop convening scientists and community representatives. Additional meetings were held that included the research team, Elders Committee and the Technical Advisory Committee. (p4)

The following research topics were selected and organized to provide guidelines for the workshops:

Environmental changes: in climate, water quality, marine currents, seasonal flow of dammed and diverted rivers, sea-ice formation, and shoreline habitat.

Natural foods and traditional societies: changes in natural food supply and drinking water; effect of road salt on ptarmigan, weakening currents and extended sea-ice cover on the Hudson Bay eider population, weather and habitat changes, increased resource competition from non-traditional activities; and increasing number of sick animals and unexplained or unusual deaths, diseases, and illnesses among indigenous residents.

Contamination: impacts on sea-bottom organisms eaten year-round by sea mammals and people; diffusion of contaminants among wildlife; bioaccumulation of methyl-mercury in fish, marine species, Cree, and Inuit

Hydroelectric development: impacts of dams, diversions and water regulation on rivers flowing into Hudson and James Bay; lack of understanding of impacts of hydroelectric development on people, communities, environment and animals; effects of altered river regimes on traditional activities, of reservoirs on climate, ice conditions, air temperature and transportation, and of transmission lines on humans, wildlife and vegetation; and cumulative effect on salinity balance, salt-water freezing, and sea-ice formation.

Forestry: effects of clear-cutting on rivers flowing into Hudson and James Bay

Future developments: impacts on harvesting traditional foods(McDonald, 1997, 71)

Ecosystem type(s): Hudson Bay bioregion

Indicators identified
Dozens of indicators are identified in the report in three appendices. The first appendix (B) lists characteristics of seasonal cycles observed by residents in various communities in the study area, which include both abiotic (temperature change, sea ice formation and so on) and biotic (bird and fish migration, caribou mating, sea mammal migration and so on) characteristics. Appendix C lists environmental indicators for various weather conditions and weather forecasting, seasonal changes and animal migrations while Appendix D specifically discusses 'environmental changes in sturgeon, snow goose, Canada goose, Beluga whale and polar bear.

In another section of the report indicators for 'regional environmental changes observed' are organized into the following categories: weather (e.g. great variability), atmosphere (e.g. change in sky colour), sea ice (e.g. freeze and

break-up times), currents (e.g. weakening currents), rivers (e.g. level and flow changes) and Canada and snow geese (changes in migration routes, increase in numbers)

	Indicators for:	Years of data	Location of monitoring	Measurement
Biotic	Seasonal characteristics identification by month. (bird & animal migrations and physical changes)	n/a	Hudson Bay bioregion	qualitative
	Sturgeon abundance	n/a	Hudson Bay bioregion	qualitative
	Snow & Canada goose migrations & abundance	n/a	Hudson Bay bioregion	qualitative
	Beluga whale migration & abundance	n/a	Hudson Bay bioregion	qualitative
	Polar bear movements & abundance	n/a	Hudson Bay bioregion	qualitative
Abiotic	Seasonal characteristics identification by month (weather & temperature)	n/a	Hudson Bay Bioregion	qualitative
	Weather forecasting: weather conditions	n/a	Hudson Bay Bioregion	qualitative

Geographic scope of indicators:

Ecozone(s): Northern Arctic, Southern Arctic, Taiga Shield, Hudson Plains

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Northwest Territories, Manitoba, Ontario, Quebec, Labrador. First Peoples: Inuit, Athapaskan, Algonkian (Cree), Labrador Inuit.

Participating communities: Repulse Bay, Coral Harbout, Chesterfield Inlet, Whale Cove, Arviat, York Factory, York Landing, Shamattawa, Ft. Severn, Peawanuck, Attawapiskat, Kashechewan, Ft. Albany, Moose Factory, Waskaganish, Wemindji, Chisasibi, Kuujjuaraapik / Shapmagoostui, Sanikiluaq, Umiujaq, Inukjuak, Akulivik, Ivujivik, Salluit, Kangiqsuguaq, Lake Harbour, Cape Dorset

Measurement framework adopted: n/a

Information available as:
Raw data:
- primary source documents comprise approximately 1800 pages translated and transcribed from 114 sixty-minute audio tapes.
- Secondary source documents include meeting guidelines, notes, map overlay text, figures and tables. (pg.73)

more than 110 map overlays of the TEK themes were produced by the working groups and organized into a GIS database by the Natural Resources Secretariat of the Manitoba Keewatinowi Okimakanak (NRS-MKO)

Trend information

Sources of Information

a.) Reports:

McDonald, Miriam, Lucassie Arragutainaq and Zack Novalinga. *Voices from the Bay: traditional ecological knowledge of Inuit and Cree in the Hudson Bay bioregion.* Ottawa; Sanikiluaq: Canadian Arctic Resources Committee; Environmental Committee of Municipality of Sanikiluaq, 1997. 98p.

Eight technical reports also were produced and are available from the Canadian Artic Resources Committee. Titles are:

Human impacts on the Hudson Bay Region, its present state and future environmental concerns
Towards the assessment of cumulative impacts in Hudson Bay
Health effects of development in the Hudson Bay / James Bay region
Climate variability, climate change, and implications for the future of the Hudson Bay bioregion
The estuaries of Hudson Bay: a case study of the physical and biological characteristics of selected sites
Native land use, traditional knowledge and the subsistence economy in the Hudson Bay bioregion
Effects of hydroelectric projects on Hudson Bay's marine and ice environments
Traditional ecological knowledge of environmental changes in Hudson and James Bays: parts I and II.

b.) Websites:

Canadian Arctic Resources Committee
http://www.carc.org/pubs/v19no3/2.htm

c.) Organization(s) responsible and Contact person(s)

Program is concluded. Report "Voices from the Bay" is sold by the
CANADIAN ARCTIC RESOURCES COMMITTEE
1276 Wellington Street , 2nd Floor
Ottawa, Ontario K1Y 3A7
Tel: (613) 759-4284
Fax: (613) 759-4581
Toll Free number: (866) 949-9006

Title of Indicator Initiative / Program
Inuit bowhead knowledge study

Initiative / Program objectives
Article 5, part 5 of the Nunavut Land Claims Agreement (NLCA) required that the Nunavut Wildlife Management Board carry out an Inuit Knowledge Study of bowhead whales in the Nunavut Settlement area. The objectives of the study were to:

> To record sightings, location and concentrations of bowhead whales in the Nunavut Settlement Area
> Document the cultural and traditional importance of bowhead hunting for inuit, and Inuit knowledge of various aspects of bowhead ecology and behaviour in the Nunavut Settlement Area
> Document changes and trends in relative abundance and distribution of bowheads from the end of commercial whaling (about 1915) to the present time.
> (Inuit Study Participants 2000, 1)

Year(s) of Initiative / Program: 1994 – 2000

Indicator development process used: local, traditional knowledge

Ecosystem type: marine

Indicators identified:

	Indicator	**Years of data**	**Location of monitoring**	**Measurement**
Biotic	Bowhead abundance	early 1900s - 2000	Foxe Basin, Hudson Strait, Hudson Bay, Baffin Bay	qualitative
	Bowhead: seasonal distribution, migration patterns & behaviour	n/a	Hudson Bay, Baffin Bay,	qualitative
	Bowheads: group size	n/a	Hudson Bay, Baffin Bay,	qualitative
	Bowhead calves occurrence	n/a	Igloolik, , Hudson Strait, Hudson Bay, Baffin Bay	qualitative
	Killer whale occurrence	1960s - 2000	Foxe Basin, Hudson Strait, Hudson Bay, Baffin Bay	qualitative
	Bowheads and sea ice	n/a	Nunavut	qualitative
	Bowhead feeding ecology	n/a	Hudson Bay, Baffin Bay,	qualitative
	Bowheads: aggression	n/a	Nunavut	qualitative
	Bowheads: age / size categories	n/a	Nunavut	qualitative
	Bowheads: strandings, net-entanglements & ice-entrapments	1950s - present	Foxe Basin, Hudson Strait, Hudson Bay, Baffin Bay	qualitative
	Bowheads: interactions with species other than killer whales	n/a	Nunavut	qualitative
Human Use	Bowhead ancestral whale hunting	n/a	Nunavut	qualitative

	Indicator	Years of data	Location of monitoring	Measurement
	Bowhead: commercial whaling	1850 - ?	Nunavut	qualitative
	Inuit: loss of knowledge about the bowhead	n/a	Nunavut	qualitative
	Inuit: culture of the bowhead hunt	n/a	Nunavut	qualitative
	Inuit: resuming the bowhead hunt	n/a	Nunavut	qualitative
	Inuit bowhead hunts after 1915	1915 - 1975	Nunavut	qualitative
	Bowhead harvesting: voluntary cessation by Inuit	early 1900s - 1979	Nunavut	qualitative
	Bowheads: Impacts of noise	n/a	Nunavut	qualitative
	Bowheads: potential impacts of oil spills / pollution from ocean-going tankers & drilling	n/a	Nunavut	qualitative
	Bowheads: impacts of hunting activities	n/a	Nunavut	qualitative
	Bowheads: occurrence of accidents with small - boat traffic	n/a	Foxe Basin, Hudson Bay, Baffin Bay	qualitative
Values	Inuit values & beliefs regarding wildlife	n/a	Nunavut	qualitative

Geographic scope of indicators

Ecozone(s): southern Arctic, northern Arctic

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Nunavut

Measurement framework adopted: n/a

Information available as: qualitative

Sources of Information

a.) Reports

Inuit Study Participants et al. 2000. *Final report of the Inuit bowhead knowledge study, Nunavut, Canada.* Iqaluit: Nunavut Wildlife Management Board. 90p.
Retrieved 4 February 2005 from the World Wide Web:
http://www.nwmb.com/english/resources/Bowheadreport.pdf

b.) Websites

Nunavut Wildlife Management Board
http://www.nwmb.com/english/

c.) Organization(s) responsible and Contact person(s)

Title of Indicator Initiative / Program
Inuvialuit traditional ecological knowledge of fisheries in rivers west of the Mackenzie River in the Canadian Arctic (TEK Fishing study)

Initiative / Program objectives
- collection traditional ecological fisheries knowledge on the area west of the Mackenzie River
- use this TEK information for incorporation into the objective-based fisheries management planning process

Year(s) of Initiative / Program: February, March 2002 with follow-up verification component in January 2003

Indicator development: participatory

Data collection: qualitative information based on TEK, mainly from the 1930's to the present.

Indicator development process used: local, traditional knowledge gathered in a series of free flowing group discussions amongst knowledgeable fishes and elders in Aklavik and Inuvik

Ecosystem type: freshwater

Indicators identified

	Indicator	**Years of data**	**Location of monitoring**	**Measurement**
Biotic	Fishery runs	n/a	Shingle Point, Running River, Big Fish River, Mackenzie River Delta	qualitative
	Changes & differences in fish species	n/a	Shingle Point, King Point, Running River, Herschel Island	qualitative
	Marine mammals observed	1950s - present	Herschel Island, Mackenzie River Delta, Margaret Lake	qualitative
Abiotic	Physical changes along the coast	1950s - present	Mackenzie River Delta, Malcolm, Firth, Babbage & Big Fish Rivers, Shingle Point	qualitative
Human Use	Fishing methods	1930's - present		qualitative
	Amount of fish caught		n/a	qualitative
	Taste preferences	n/a	n/a	qualitative

Geographic scope of indicators:
five rivers along the north slope of the Yukon and NWT (Big Fish River, Blow River, Babbage River, Firth Rive and the Malcolm River) and several mainland sites: Single Point / Running River, Kay Point / Philips Bay, Nunaluk Spit, Prarmigan Bay Herschel island and Komakak Beach / Fish Creek.

Ecozone(s): Southern Arctic, Taiga Plains, Taiga Cordillera, Boreal Cordillera
Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Federal government (DFO), Yukon Territory, Aklavik Hunters and Trappers Committee, Aklavik Elders Committee, Fisheries Joint Management Committee

Measurement framework adopted: n/a

Information available as: synthesized qualitative information

Sources of Information

a.) Reports
Papik, **Richard**
Marschke, **Melissa**
Ayles, **G. Burton**
Canada/Inuvialuit Fisheries Joint Management Committee
Inuvialuit traditional ecological knowledge of fisheries in rivers west of the Mackenzie River in the Canadian Arctic. Inuvik, NT,: Canada/Inuvialuit Fisheries Joint Management Committee, 2003, v, 19p.
Series title: Technical report /2003-4
URL: http://www.fjmc.ca/publications/Report%202003-4%20Marschke%20May%2022(final)%20e-copy%20(Compressed).pdf

b.) Websites
http://www.fjmc.ca/

c.) Organization(s) responsible and Contact person
Andrea Hoyt
Community Resources Specialist
Fisheries Joint Management Committee
Box 2120
Inuvik, NT
X0E 0E0
fjmc-rp@jointsec.nt.ca

Title of Indicator Initiative / Program
Kluane Alpine Ecosystem Project (Yukon)

Initiative / Program objectives
Studies are being conducted on four key mammalian herbivores and alpine vegetation in several communities. These experiments will provide detailed information about the processes which determine the structure of naturally fragmented alpine terrestrial ecosystems, and in particular, the influence of herbivory and climate variability. Alpine regions in general, and the Kluane region specifically, are expected to undergo large changes in community structure in response to global warming. [Retrieved 1 February 2005 from the World Wide Web: http://www.biology.ualberta.ca/faculty/david_hik/index.php?Page=996]

Year(s) of Initiative / Program: on-going

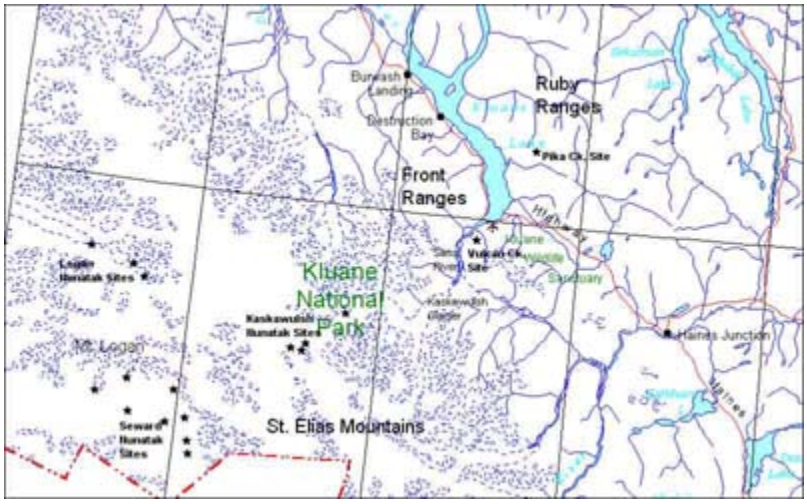
Indicator development process used: scientific knowledge & methods

Ecosystem type: terrestrial (alpine)

Indicators identified

	Indicator	**Years of data**	**Location of monitoring**	**Measurement**
Biotic	Population Dynamics of Collared Pikas (*Ochotona collaris*): Demography, genetics and population dynamics of collared pikas (Ochotona collaris) on meadows of different productivity and degree of isolation; metapopulation dynamics; forage selection by collared pikas; genetics	1996 -	Kluane	
	Social Behaviour and Dynamics of Hoary Marmots: population dynamics; social behaviour; genetics	1996 -	Kluane	
	Dall's Sheep, effects of habitat change: horn growth; effects of climate change	n/a	Kluane	
	Arctic Ground Squirrels population dynamics; habitat use; social behaviour	n/a	Kluane	
	Impacts of Mammalian Herbivory on Alpine Meadows: patterns of grazing and overcompensation; photosynthetic responses to grazing	n/a	Kluane	
	Biodiversity (alpine) in the southwest Yukon: Comparison of the biodiversity of alpine communities of different glacial histories	n/a	Kluane	
Abiotic	Climate Change impacts: Effects of climate warming and nutrient addition (passive warming experiments); Effects of delayed snowmelt (shovelling experiments)	n/a	Kluane	

Field sites are located along an 100 km environmental gradient extending from the St. Elias Icefields of Kluane National Park, through the surrounding Front Ranges, and across Kluane Lake into the Ruby Ranges. These sites include a number of alpine meadow communities of similar elevation (around 2000 m) which have experienced different climatic and glacial histories. The main field camp (PIKA CAMP) is located in the Ruby Ranges (nearly continuously vegetated slopes), and is accessible by vehicle and foot. Remote sites in the Front Ranges, where meadows are interspersed on mountain ridges resulting in a higher degree of fragmentation, and the Icefield Ranges, where highly fragmented communities exist on nunataks, are accessed by aircraft. Facilities at the AINAresearch station at Kluane Lake serve as a base for our field operations.



[Retrieved 1 February 2005 from the World Wide Web:
http://www.biology.ualberta.ca/faculty/david_hik/index.php?Page=996]

Geographic scope of indicators

Ecozone(s): Boreal Cordillera

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Yukon Territory

Measurement framework adopted: n/a

Information available as:

Sources of Information

a.) Reports

b.) Websites: http://www.biology.ualberta.ca/faculty/david_hik/index.php?Page=996

c.) Organization(s) responsible and Contact person(s)
Dr. David Hik
University of Alberta
Faculty of Science, Biological Sciences

Title of Indicator Initiative / Program
Kluane Ecological Monitoring Project (KEMP)

Initiative / Program objectives
- study the organization of the vertebrate community in the Kluane region of the Yukon
- "needed to know the abundance of all the major species, their food habits, and how thee change over time." (Krebs 2001, p.5)

Study focused on community organization by describing the food web, estimating the consumption of each species in the food web by combining the diet information with abundance data and then put together an arithmetic balance sheet for the entire community. Lastly, the scientists experimentally disturbed the system and observed the responses. 1-km2 blocks of boreal forest were manipulated for 10 year time scale.

Year(s) of Initiative / Program: 1986 - ongoing
Data collection: ongoing. Data available in Excel at: http://www.zoology.ubc.ca/~krebs/kluane.html
Since the close of the Kluane Boreal Forest Ecosystem Project in 1996 (Krebs, Boutin and Boonstra, 2001), we have continued to monitor a variety of plant and animal indicator species in the Kluane region. We have developed a set of monitoring procedures and we maintain an excel file which summarizes all the data collected to date. We are happy to share these data with all interested people, but since they have not yet been published, we request that you obtain permission from me before using or publishing them in any form. [website January 20, 2005 http://www.zoology.ubc.ca/~krebs/kluane.html]

Indicator development process used: scientific knowledge & methods

Ecosystem type: terrestrial

Indicators identified: listed in detail in this publication:
ftp://ftp.zoology.ubc.ca/pub/krebs/KEMP_Annual_Report_2003.pdf

	Indicator	**Years of data**	**Location of monitoring**	**Measurement**
Biotic				Tree health with respect of spruce bark beetle attack & growth rates of trees are recorded. Survival of spruce seedlings and sapling is monitored in harvested & unharvested areas.
	White spruce cone production			Annual rates of cone production are documented
	Soapberry production			Soapberry production each year is recorded
	Ground berry production			Annual berry production is recorded for crowberry, bearberry, red bearberry, and cranberry
	Mushrooms: standing crop			Standing crop of mushrooms is recorded in early August each year as an index of mushroom fruiting.
	Snowshoe hare abundance			Relative density of hares documented from pellet plots annually
	Breeding bird surveys & point counts for passerine and landbirds			Breed bird surveys & point counts are completed annually

	Indicator	Years of data	Location of monitoring	Measurement
	Predator abundance		Kluane Lake – Sulphur Lake corridor	An annual index of relative abundance of coyotes, lynx and other predators is derived from a winter track transect
	Great horned owl census		Between Kluane Lake and Hungry Lake	Annual population density estimate based on breeding pairs
	Snowshoe hare abundance		Sulphur, Silver and Jacquot Island monitoring grids	Population density estimates calculated from live trapping hares twice per year
	Red squirrel & ground squirrel abundance			Population density estimates calculated from live trapping squirrels twice per year at two monitoring grids
	Small mammal abundance			Population density estimates calculated from live trapping mice and voles twice per year at three monitoring grids
	Shrub growth			Annual production index carried out on tagged willow & birch shrubs on four monitoring grids
	Shrub browse			Rate of loss of tagged twigs of willow and birch due to browsing is documented
	Ungulate & salmon surveys	1976 - ongoing		Aerial surveys of moose, sheep & goal populations in or adjacent to Kluane NP & R
	Red squirrel ecology & population dynamics	1986 - ongoing		n/a
	Snowshoe hare & small mammal ecophysiology	1991 - ongoing		n/a
	Pika & marmot abundance & population dynamics (see Kluane Alpine Ecosystem Project)	1996 - ongoing		n/a
	Vegetation: dynamics	1989 - ongoing		n/a
	Primary productivity: NDVI measurements	1993 -- 2002		10-day composite satellite images monitor length of growing season & a coarse index of primary productivity recorded by ecodistrict
Abiotic	Weather			Temperature, precipitation, days with 25 cm of more of snow cover recorded several times each day at six monitoring transects

	Indicator	Years of data	Location of monitoring	Measurement
	Snow pack thickness	1976 - ongoing		Thickness of snow pack is measured at four snow stations from February to March each year

Geographic scope of indicators:

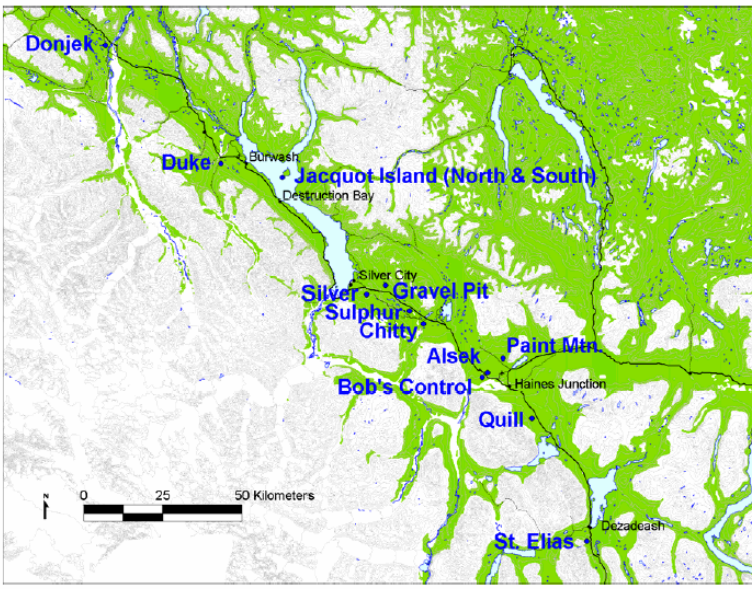
Ecozone(s): Boreal Cordillera

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Yukon Territory and Champaign-Aishihik and Kluane First Nations

Measurement framework adopted: food web

Information available as:
Raw data: yes
Trend information: yes

Map of monitoring sites:



KEMP study area. Monitoring sites are labeled in blue.

ftp://ftp.zoology.ubc.ca/pub/krebs/KluaneMonitoringManual2004.pdf
Retrieved from the World Wide Web January 26, 2005

Sources of Information

a.) Reports
Krebs, Charles J., Stan Boutin and Rudy Boonstra, eds.
Ecosystem dynamics of the boreal forest: the Kluane Project. New York: Oxford University Press, 2001. 511p.
This book describes the Kluane Boreal Forest Ecosystem Project which operated from 1986 to 1996 in the southwestern Yukon. It begins by describing the area and its physical setting, and then the background of the project and the wisdom that had accumulated to 1986, on how this system might operate. The details of the experiments set up are presented, partly to help the reader appreciate the difficulty of working at -40 degrees and partly to aid the

reader should they contemplate doing similar experiements in the future. Then they examine the three trophic levels of plants, the herbivores, and the predators in detail to provide some surprises about how the individual species operate within the overall system. Finally, they synthesize their findings in a model of the boreal forest vertebrate community, and provide an overview of what they have discovered and what remains to be done. Over the ten years of this project the 8 faculty members from three Canadian universities and 26 graduate students joined with 75 summer assistants and 18 technicians to expend 153 person-years of effort to produce the picture they develop here. No one ever thought that ecology was a simple subject like chemistry, but when they began this project they hoped to join forces to make a major advance in our understanding of the boreal forest ecosystem.

Henry, J. David et al.
The Kluane Ecological Monitoring Project annual report 2003. Haines Junction, YT, : Kluane Ecological Monitoring Project, 2003, 25p.
Other title: KEMP annual report
Abstract: The purpose of this annual report is to summarize for managers and interested members of the public some of the major, current findings of the monitoring program as well as other relevant research programs. The report begins with an overview of KEMP. Selected research findings outside of KEMP but relevant to the monitoring project are also summarized in this report. Regarding the KEMP protocols, patterns of general interest or findings with management implications are the main focus of this report. Further details can be obtained by referring to the references cited here. This annual report is intended to be a standing report that the KEMP team adds to, edits or changes in appropriate ways once each year.
URL: ftp://ftp.zoology.ubc.ca/pub/krebs/KEMP_Annual_Report_2003.pdf

Kluane Monitoring Handbook
ftp://ftp.zoology.ubc.ca/pub/krebs/KluaneMonitoringManual2004.pdf

b.) Websites:
Kluane Monitoring website
http://www.zoology.ubc.ca/~krebs/kluane.html

c.) Organization(s) responsible and Contact person(s)
Charles J. Krebs
Department of Zoology at UBC (krebs@zoology.ubc.ca)
OR
Liz Hofer at Kluane (ehofer@yknet.yk.ca).

Title of Indicator Initiative / Program
Lower Hyland River Wildlands Study

Initiative / Program objectives
This report is one in a series of conservation studies and management proposals, produced by CPAWS-Yukon, for natural landscapes and watersheds in the southeast Yukon. [website 31 January 2005 http://www.cpawsyukon.org/resources/publications-reports.html
The objectives are to:

- to inform and support the implementation of ecosystem-based planning exercises in the southeast Yukon
- to identify at several spatial scales those areas that must be set-aside from development in order to ensure that fully functioning ecosystems will persist
- more specifically, to identify many of the conservation values of the Hyland River watershed and recommend approaches for managing such values in areas where harvesting has been deemed appropriate and consistent with ecosystem-based plans

Year(s) of Initiative / Program: two field reconnaissance survey trips were conducted by traveling the Hyland River. The first trip was conducted from the Green River to the Yukon border May 28 – June 1, 2001, while the second trip occurred in the upper reaches of the study area from Conglomerate Creek to the Yukon Border August 4 – 21, 2001.

Indicator development process used: scientific knowledge & methods

Ecosystem type: northern river basin

Indicators identified

	Indicator	**Years of data**	**Location of monitoring**	**Measurement**
Biotic	Plant communities & species composition	2001	Lower Hyland River	Plant communities & species composition were identified during field stops with additional observation made while traveling down the river and from aerial photos & forest cover maps
	Bird species richness	2001	Lower Hyland River	Systematic bird surveys were done over a period of 5 days from the Green River to the Alaska Highway (112 river km) in habitats along the river & casual observations of birds were recorded during the second field trip
	Mammal species	2001	Lower Hyland River	Presence of mammals was recorded (observed mammals or tracks) and relevant research reports and unpublished data & information summarized
	Amphibian & fish species	2001	Lower Hyland River	Wetland near the Hyland River were searched for amphibians; fish sampling consisted of opportunistic angling for sport fish species
	Species at risk under COSEWIC	2001	Lower Hyland River	Those on the COSEWIC found in the survey area
	Regionally specific species	2001	Lower Hyland River	List of those found in the study area
Human use	Traditional & subsistence use of the forest	2001	Lower Hyland River	Derived from other research

	Indicator	Years of data	Location of monitoring	Measurement
	Trapping: trapping areas & species harvested	2001	Lower Hyland River	Revenues generated from fur harvest (Yukon), registered trapping areas & species most frequently harvested
	Tourism: extent of activities	2001	Lower Hyland River	Description of tourism services offered

Geographic scope of indicators

Ecozone(s): Boreal cordillera ecozone. The Hyland watershed lies within two ecoregions – the upper half within the Selwyn Mountains ecoregion and the lower half in the Liard Basin ecoregion (p7)
Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Yukon Territory

Measurement framework adopted

Information available as: raw data

Sources of Information

a.) Reports
Canadian Parks and Wilderness Society. Yukon Chapter. The lower Hyland River wildlands study: background report and recommendations for ecosystem-based forest management in the Hyland River watershed. [s.l.] CPAWS-Yukon, 2004. 96p.
Retrieved 1 February 2005 from the World Wide Web:
http://www.cpawsyukon.org/resources/cpawsyukon-hyland-report.pdf

b.) Websites
CPAWS Yukon: http://www.cpawsyukon.org/

c.) Organization(s) responsible and Contact person(s):
Address:
Canadian Parks and Wilderness Society. Yukon Chapter
P.O. Box 31095
211 Main St.
Whitehorse, Yukon
Y1A 5P7
Telephone: (867) 393-8080
Fax: (867) 393-8081
General Inquiries: info@cpawsyukon.org

Title of Indicator Initiative / Program
Mackenzie River Basin State of the Aquatic Ecosystem

Initiative / Program objectives
"*The Board's State of the Aquatic Ecosystem Report used these goals as indicators to measure the environmental health of the Mackenzie River drainage basin."* (p.2)
- improve water quality
- ensure sufficient water quantity
- sustain in-stream water uses
- ensure healthy, abundant and diverse aquatic species and habitat
- ensure human health and safety
- ensure a knowledgeable and involved public

Year(s) of Initiative / Program: 1997 – ongoing

Indicator development process used: local, traditional knowledge and scientific knowledge & methods

Ecosystem type: northern river basin

Indicators identified

	Indicator	**Years of data**	**Location of monitoring**	**Measurement**
Biotic	Traditional knowledge of aquatic species & habitat	Before 1995 2000 Before 1995 1950s – 1990s	Athabasca sub-basin Peace sub-basin Liard sub-basin Peel sub-basin Great Slave sub-basin Mackenzie – Great Bear sub-basin	qualitative
	Aquatic & riparian-dependent wildlife species at risk	2003	Athabasca sub-basin Peace sub-basin Liard sub-basin Great Slave sub-basin	Number of species
	Waterfowl: population trends	1995 – ongoing 1961 – 2001	Athabasca sub-basin Western NWT	Population size Population estimates
	Fish populations	n/a	Great Slave sub-basin	qualitative
Abiotic	Water quality: TEK	Before 1995	Fort McMurray Peace sub-basin Great-Slave sub-basin	qualitative
	Water quality: dissolved phosphorous	1977 – ongoing	Athabasca sub-basin	Milligrams per litre
	Water quality: Dissolved oxygen	1991 - 2003	Athabasca sub-basin	Minimum wintertime levels of dissolved oxygen (milligrams per litre, average over seven day period)
	Water quality index (Alberta)	1996 - 2001	Athabasca and Old Fort Smoky and Peace Rivers	Measurements of metals, nutrients, bacteria & pesticides in water samples

	Indicator	Years of data	Location of monitoring	Measurement
	Water quantity: annual flow (average) (average) (average) (peak) (average) (peak) (spring freshets) (average)	1960 – 2000 1960 – 1999 1960 – 1995 1955 – 2000 1960 – 2000 1960 – 2000 1950 – 2000 1950 – 2000 1961 - 2001	Athabasca sub-basin Peace River Smoky River Liard River Peel River Great Slave sub-basin Great Slave sub-basin Great Slave sub-basin Mackenzie – Great Bear sub-basin	Cubic metres per second / averaged each year Date of peak spring discharge Date of spring freshet
	Water quality: fish consumption advisories	2003	Athabasca sub-basin Peace sub-basin Great Slave sub-basin Mackenzie – Great Bear sub-system	Location of advisories No. lakes / species with fish advisories No. lakes / species with fish advisories
	Water quantity: Lake & river water level	1930 – 2002 Before 1995 n/a n/a	Lake Athabasca Peace sub-basin Great Slave sub-basin Mackenzie Great Bear sub-basin	Metres Qualitative (TEK) Qualitative (TEK) Qualitative (TEK)
	Water quality: organic matter in pulp mill effluents	1990 - 2000	Slocan (Taylor) Abitibi (Mackenzie) Weyerhaeuse (Grande Prairie) Pope & Talbot (Mackenzie) Daishowa (Peace River)	BOD (tonnes per day)
	Water quality: absorbable organic halides	1990 - 2000	Peace River at Fort Vermillion Smoky River at Watino Weyerhauser (Grande Prairie) Pope & Talbot (Mackenzie) Daishowa (Peace River)	Median AOX (milligrams per litre – Fort Vermillion & Waterino). Other locations: AOX tonnes per day
	Water quantity: snowpack accumulation	1960 -1995	Grande Prairie, Smoky River	Total winter precipitation in centimeters each year
	Water quality: % frequency that water exceeded Canadian Env. quality guidelines for aquatic life since the 1980s	1980 - ongoing	Liard sub-basin	
	Water quality: sewage effluent	2003	Liard sub-basin	Sewage treatment type / % population

	Indicator	Years of data	Location of monitoring	Measurement
			Mackenzie – Great Bear sub-basin	Amt. Treated wastewater discharge by community
	Water quantity: seasonal patterns of flow	1960 – 1984 & 1985 – 1995	Liard River	% of annual flow / month
	Rivers: flooding	1828 – 1999	Liard River	Number of floods per quarter century
	Water quality: zinc concentrations	1991 - 2002	Peel sub-basin	Milligrams per litre for month of highest concentration each year
	Water quality: % samples exceeding Canadian Env. Quality guidelines	2003	Great Slave sub-basin Mackenzie – Great Bear sub-basin	
	Water quality: arsenic contamination	1900 – 2000	Yellowknife Bay	Arsenic concentration (parts per million)
	Water quality: turbidity	1960 - 2000	Mackenzie – Great Bear sub-basin	% exceedances of guidelines
Human Use	River: aboriginal (travel, recreation, fishing)	Before 1995	Athabasca sub-basin Peace sub-basins	Qualitative
	Water allocations	2003	Athabasca sub-basin Peace sub-basin Liard sub-basin Mackenzie – Great Bear sub-basin	% allocated / sector Water use / community / year
	Commercial fish harvest	1990 – 1999 1990 – 2000 1945 – 2000 1972 – 1990	Athabasca sub-basin Peace sub-basin Liard sub-basin Great Slave sub-basin Mackenzie – Great Bear sub-system	Tonnes / year Tonnes / year Thousands / year
	Harvest of semi-aquatic furbearers	1992 – 2001	Athabasca sub-basin	Thousands of pelts / year
	River tourism	1999 - 2001	Peel sub-basin	Number of user days
	River: subsistence fish harvest	1995 - 2001	Peel sub-basin	Number of fish harvested / year

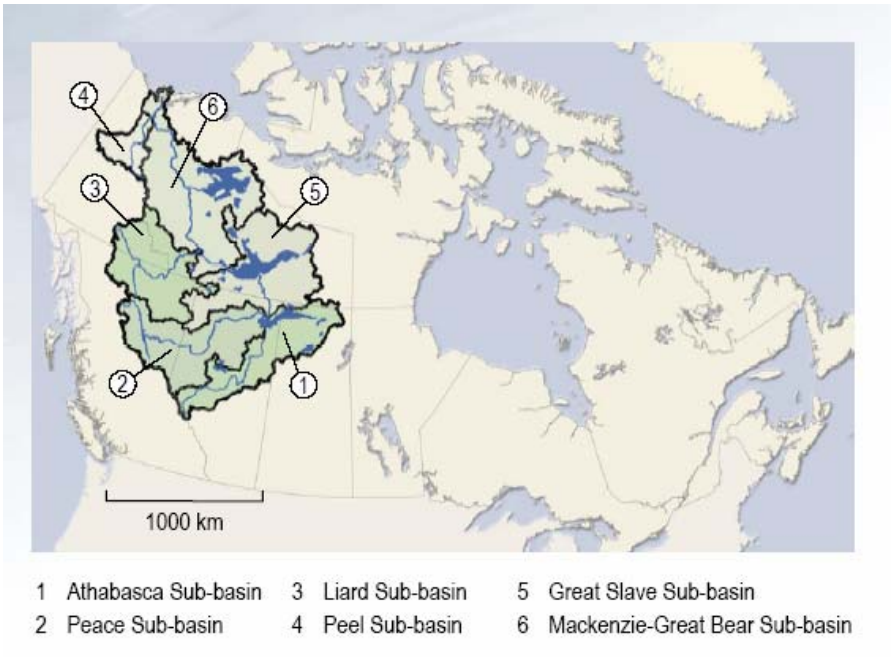
	Indicator	Years of data	Location of monitoring	Measurement
	Ferry & ice bridge operation	1990 - 1999	Mackenzie – Great Bear sub-basin	Days of operation

Geographic scope of indicators

Ecozone(s): Taiga plains

Sub-basins: Athabasca, Peace, Liard, Peel, Great Slave, Mackenzie-Great Bear

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries:
Canada, British Columbia, Alberta, Saskatchewan, the Northwest Territories and Yukon (the governments with jurisdiction to manage water and the environment in the Mackenzie River Basin) have signed the Mackenzie River Basin Transboundary Waters Master Agreement. It came into effect in July 1997.



http://wlapwww.gov.bc.ca/wat/aq_eco_rep/pdfs/whole_basin.pdf
(put in citation p 16)

Measurement framework adopted: n/a
Information available as: trend

Sources of Information

a.) Reports
Mackenzie River Basin Board
Mackenzie River Basin state of the aquatic ecosystem report 2003. Fort Smith, NT, : Mackenzie River Basin Board Secretariat, 2003, 208p.
Abstract: Completed in March 2004, this report aims to: 1) Help decision makers and local residents understand the current state of aquatic ecosystems in the Mackenzie River Basin; 2) Identify gaps in knowledge and management practices and suggest possible improvements: and 3) Provide an opportunity to highlight the value of Traditional

Ecological Knowledge (TEK) as an integral component in ecological assessment. The Board is pleased to present highlights from their report in this summary.
URL: http://wlapwww.gov.bc.ca/wat/aq_eco_rep/eco_reports.html

b.) Websites: http://www.mrbb.ca/default.asp

c.) Organization(s) responsible and Contact person(s)

Jack VanCamp, Executive Director Mackenzie River Basin Board Secretariat
Box 1349, Fort Smith, NWT, X0E 0P0
Phone (867) 872-2375 Fax (867) 872-2385
mailto:Jack.VanCamp@EC.gc.ca

Title of Indicator Initiative / Program
Mortality of Moss

Initiative / Program objectives
Publish a journal article, which is in preparation**.**
Bellow, Richard, Anna Abnizova and Elizabeth Miller**.** Drought induced degeneration of Dicranum moss and implications for pleat plateau carbon budgets in the Hudson Bay lowland.

Year(s) of Initiative / Program: June 2003 and ongoing

Indicator development process used: scientific knowledge & methods

Ecosystem type: polygonized peat plateau

Indicators identified: *severe historical drought is indicated by the simultaneous onset of mortality in moss growing in zones of moisture stress, dimple depths and growth rates combined with stratigraphy provide basis for dating*

Historic length of indicator *This investigation has not involved long-term monitoring to date, but rather interpreting the timing and cause of the onset of moss degeneration from moss morphometry, and spatial pattern indicators.*

Geographic scope of the indicator(s): *one peat plateau (4 ha) approximately 5 km from the coast of Hudson Bay near the CNSC in Churchill Manitoba*

Ecozone(s):

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Manitoba, Churchill Wildlife Management Area

Measurement framework adopted: *plant inventory supported by soil moisture and temperature, sunlight and chamber CO2 measurements*

Data sources: scientific, statistical

Data and information gaps (if any): *phenomenon identified based on 12- 25 m^2 sample sites, extent in other plateaux unknown*

Sources of Information

a.) Reports
Article to be published soon

b.) Websites: n/a

c.) Organization(s) responsible and Contact person(s):
Rick Bello
Churchill Northern Study Unit and University of York
(bello@yorku.ca)

Lessons learned: reliability of indicator data (*degeneration is easily identified*;) do the indicators support program objectives(,*the longevity of moss community (50+ years) limits proxy climate information to periods shorter than this*) do they help the analysis of data or trend analysis,(*better suited to severe droughts and corresponding episodic changes in vegetation as opposed to trends)* are they used in synthesis reports (?), are they also communication tools (*visually striking indicator of climate change*),)

Title of Indicator Initiative / Program
Northern Contaminants Program Projects for 2004-2005

Initiative / Program objectives
The Northern Contaminants Program (NCP) was established in 1991 in response to studies which showed the presence of contaminants in the Arctic ecosystem. Many of these contaminants had no Arctic sources. The three main contaminant groups of concern are persistent organic pollutants (POPs), heavy metals and radionuclides. Some of these contaminants are found at unexpectedly high levels in animals at the top of the food chain and in humans. The NCP is led by Indian and Northern Affairs Canada and brings together federal departments (Indian and Northern Affairs Canada, Health Canada, Environment Canada, and Fisheries and Oceans Canada), the three territorial governments (Yukon, Northwest Territories, and Nunavut), northern Aboriginal peoples' organizations (Council of Yukon First Nations, Dene Nation, Inuit Tapiirit Kanatami, and Inuit Circumpolar Conference - Canada) and university researchers.

Between 1991-1996, NCP research was focussed on assessing where contaminants were found in the Arctic, at what levels, and confirming the source region. From 1998 -2003, under Phase II, the NCP shifted towards a greater emphasis on human health research, developing effective community dialogue, increasing community participation, and working towards international agreements to control the release of contaminants. Three of these agreements have now come into force. Under the current phase of the NCP, the focus is on protecting Aboriginal health and safety as a result of exposure to contaminants from consuming traditional/country foods, and on fulfilling Canada's obligations under international agreements.
Retrieved 3 February 2005 from World Wide Web:
http://www.ainc-inac.gc.ca/ncp/summ0405/for_e.html
Note: monitoring data also is used for Stockholm Convention reporting.

Year(s) of Initiative / Program: 1991 – ongoing

Indicator development process used: scientific knowledge & methods

Ecosystem type: coastal, freshwater, marine

Indicators identified

Indicator	Length of data	Location of monitoring	Measurement
organochlorine and metal contaminants in fish	1993 - ongoing	Laberge Lake, Kusawa Lake, Mackenzie River at Fort Good Hope	The presence of **mercury** will be tested for in the liver and muscles of the fish. During analysis each fish will have their length, weight, age, gender, sexual maturity, gonodal somatic indices, liver somatic indices, abnormalities, and parasites recorded. A small section will also be achieved for the Yukon tissue archive with the results included in the Yukon contaminants database. Burbot will be collected from the Mackenzie River at Fort Good Hope. Liver samples will be analysed for **chlorinated pesticides** and PCBs whereas liver and muscle will be analysed for mercury, **selenium** and **arsenic**. This year's results will be statistically compared to previous results and a suite of other biological parameters (such as size, age, etc) to assess temporal trends and the factors affecting those trends.
organochlorine (OC) and metal	1993 - ongoing	Laberge Lake, Quiet Lake,	The compounds of interest in this project are **brominated flame retardants** (i.e. HBCDD),

Indicator	Length of data	Location of monitoring	Measurement
contaminants in traditional/country food (burbot and lake trout)		Kusawa Lake, Great Slave Lake,	fluorinated organic compounds, short/medium chain **chlorinated paraffins** (SCCPs/MCCPs), and **polychlorinated naphthalenes (PCNs)**. All of these compounds will be analysed in trout muscle and liver samples.
new and emerging organohalogen contaminants in marine mammals.	2004 -	Hendrickson Island, Arctic Bay, Pond Inlet, Hall Beach, Arviat, Pangnirtung, Iglulik	The main focus of the analysis will be on a list of priority contaminants, including brominated flame retardants, chlorinated paraffins, and fluorinated organic compounds.. The project will focus on marine mammals for which archived samples are available from multiple years. The analytical program will involve the analysis of 10 samples per species, per location, per collection year, where samples are available.
levels of persistent organic pollutants (POPs) and metals contaminants in char that are returning from the ocean	2004 - ongoing (? Might be a continuation of monitoring that started in 1993	Paulatuk, Gjoa Haven, Pangnirtung	The char will be collected from various locations throughout Nunavut and the levels of **persistent organic pollutants (POPs)** and metals will be determined from the samples. East-west differences between POPs and metal concentrations will be investigated and will contribute to present data sets. Other factors will be taken into consideration when the contamination levels in the fish are examined, such as age, sex, **trophic level**, and climate. Some char livers will be analysed for POPs and mercury and compared to the levels commonly found in landlocked char, seals, and beluga.
changes in the amount of contaminants measured in landlocked Arctic char over time	early 1990s - ongoing	Resolute Lake, Boomerang Lake, Sapphire Lake, North Lake, Aqiatusuk Lake, Char Lake, Lake Hazen,. Amituk Lake	Fish from Resolute Lake, Char Lake, Lake Hazen and Amituk Lake will be analysed for POPs, such as polychlorinated biphenyls (PCBs), chlorinated pesticides (e.g. DDT), and brominated flame retardants (BFRs). Sediment cores have already been collected from Amituk Lake and Char Lake to investigate historic trends of contaminant input to the lakes from the surrounding environment.
contaminant concentrations in Arctic air	1992 - ongoing	Alert, Nunavut,	Particulate matter and gas phase contaminants will be sampled weekly and subsequently analysed for OCs, **polybrominated diphenyl ethers (PBDEs)**, and PAHs. Recently, the suite of chemicals measured by this project was revised to include PBDEs, endosulfan II, and 2 methyl-naphthalenes, which have become a growing concern internationally.
temporal trends of atmospheric mercury	1995 - ongoing	Alert, Nunavut	Air samples will be investigated in order to determine how mercury is transformed and then deposited into the environment. Chemical and physical aspects will also be analysed in order to determine why these mercury events occur after polar sunrise.

Indicator	Length of data	Location of monitoring	Measurement
new chemical contaminants (brominated flame retardants (BFRs), chlorinated naphthalenes (PCNs), chlorinated paraffins (CPs), and fluorinated sulfonic and alkanoic acids) in Arctic seabirds	2004 -	Prince Leopold Island, Resolute (Qausuittuq)	Seabirds will be analysed for BFRs, PCNs, short and medium chain CPs (SCCP/MCCP), perfluoro acids, and neutrals.
spatial patterns of contaminants in polar bears	2001 - ongoing	Southern Beaufort, Resolute Bay, Northern Baffin Island, Southern Baffin Island, Western Hudson Bay	tissues of polar bears collected across Canada in 2001-2002. were analyzed for POPs. This data set includes both legacy POPs, new POPs and some metabolites (e.g. methylsulfone PCBs). Stable **isotopes** of nitrogen and carbon will be measured in order to gain a better understanding of the difference in levels of contaminants between polar bears of different regions.
levels and temporal trends of mercury and persistent organic pollutants (POPs) in western Arctic and Arviat beluga, walruses and narwhal from Arctic Bay, Broughton Island, and Pond Inlet.	2004 - ongoing	Pond Inlet,. Arctic Bay, Hall Beach, Iglulik, South East Baffin,. Broughton Island, Inukjuaq,. Akulivik, Hendrickson Island	Three species, narwhal, walrus, and beluga, will be collected throughout the Arctic. All species will be analysed for mercury and POPs. Some analyses will be carried out on archived samples of narwhal, walrus and beluga.
changes in the concentrations of contaminants, such as polychlorinated biphenyls (PCBs) and mercury in ringed seals	2004 - ongoing	Arctic Bay, Resolute, Gjoa Haven, Pond Inlet, Arviat	The blubber of female seals from Arviat, Resolute, Arctic Bay and Gjoa Haven will be analysed for PCBs, **organochlorines (OCs)**, **toxaphene** and polybrominated diphenyl ethers (PBDEs). The samples from Pond Inlet, Arviat and Resolute will be analysed for metals such as mercury, **lead**, **arsenic**, **selenium**, and **cadmium**.

Geographic scope of indicators

Ecozone(s):

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Yukon Territory, Nunavut, Northwest Territories, Federal government (INAC)

Measurement framework adopted: n/a

Information available as: trend information

Sources of Information

a.) Reports

Canada. Indian and Northern Affairs. *Northern contaminants program: summary of projects for 2004 -2005.* [Ottawa]: INAC.
Retrieved 3 February 2005 from the World Wide Web: http://www.ainc-inac.gc.ca/ncp/summ0405/summ0405_e.html

b.) Websites:

Northern Contaminants Program
http://www.ainc-inac.gc.ca/ncp/index_e.html

c.) Organization(s) responsible and Contact person(s)

Northern Science and Contaminants Research Directorate
Indian and Northern Affairs Canada
10 Wellington Street
Hull, Quebec
K1A 0H4
Fax: 819-953-9066

Russel Shearer
Manager, Northern Contaminants Program
Tel: 819-994-7484
shearerr@ainc-inac.gc.ca

Title of Indicator Initiative / Program
Protecting the Beverly and Qamanirjuaq Caribou and Caribou Range

Initiative / Program objectives
The Beverly and Qamanirjuaq Caribou Management Board was created to help manage two caribou herds whose migratory routes straddle two territories, two provinces, and four different native cultures. The board consists of 14 members, including a chairman and vice chairman. Appropriately, since the main purpose of the board is to safeguard the caribou herds in the interest of aboriginal people who have traditionally relied upon caribou, the majority of board members represent aboriginal communities [website: retrieved from the website January 2005. http://www.arctic-caribou.com/about.html]

The BQCMB's overall goal and management objective concerning protection of caribou and caribou range:
- to protect caribou and their habitat from human disturbance
- to maintain sufficient high quality caribou range over the long-term to support high populations of caribou, so although populations may decline periodically, adequate range is available to allow populations to increase when factors permit.

Year(s) of Initiative / Program: 1982 – ongoing
In 1996, the Beverly and Qamanirjuaq Caribou Management Board took steps to research and map out the most important habitats of the Beverly and Qamanirjuaq ranges, in light of growing mineral exploration and other industrial developments in Canada's North.

Indicator development process used: local, traditional knowledge and scientific knowledge & method. Some community-based monitoring

Ecosystem type: Terrestrial

Indicators identified

	Indicator	**Years of data**	**Location of monitoring**	**Measurement**
Biotic	Caribou herd size estimates	1972 - 1994		Beverly Herd: visual estimates from aircraft up to 1980, plus 1987; aerial photo census in other years. Qamanirjuaq Herd: visual estimates from aircraft up to 1982; aerial photo census in the years following 1982.
	Caribou herd range & movements	1940's - ongoing (TEK and scientific)	Range of the herds	Adult females are monitored using radio-collars. Elders are surveyed (qualitative). Published reports
	Caribou: water & ice crossings	n/a		Reports & personal observations of biologists.
	Caribou: spring classification surveys	1994 – ongoing 1994 - 1995	Qamanirjuaq herd Beverly herd	Calf:cow ratio
	Caribou: physical condition	Ongoing (qualitative)		TEK – survey of hunters
	Caribou: locations of calving caribou	1957 – 1994 1963 – 1994	Beverly herd Qamanirjuaq herd	Amount & quality of information varies.

	Indicator	Years of data	Location of monitoring	Measurement
				Mainly based on surveys and observations during flights to monitor land use activities
Abiotic	Contaminants in caribou	n/a	Beverly herd	
	Climate change: seasonal temperatures	1946 - 1996	Baker Lake, Fort Smith, Brochet, Stony Rapids	Source: Environment Canada. Trend lines are based on linear regression models
	Rivers: freeze-up & break-up dates	1968 - 1995	Dubawnt, Kazan, Cochrane rivers	Dates of freeze-up & break-up each year
Human Use	Road development: leases & permits issued	1991 – 1998 NWT portion)	Beverly herd range and NWT portion of range	
	Mineral exploration and mines: permits & leases issued	1991 – 1998 (NWT portion)	Ranges of herds, especially in Sask., western NWT & Nunavut.	
	Food, clothing & shelter	TEK (qualitative)		qualitative
	Airstrips & low-flying aircraft: leases & permits for airstrips	1991 – 1998 (NWT portion)	NWT portion of range	
	Airplane flights / year	1979 - 1999	Lac Brochet, Rankin Inlet, Fort Smith	Aircraft Movement Statistics
	Tourism development: leases for fishing & hunting camps	1991 – 1998 (NWT portion)	Range of herds	Leases for tourism developments (small scale tent camps to major lodges)
	Human population dependent on herds	1971 - ongoing	NWT and Nunavut	Based on census data for 1971-96, population estimates for 1999, and population projections for 2019/20 (NWT communities in 2019 and NU communities in 2020

Geographic scope of indicators: range of the herd. The Beverly and Qamanirjuaq barren-ground caribou herds range through the Southern Arctic tundra and sub arctic taiga of the western NWT, Nunavut, northern Manitoba, Saskatchewan and Alberta.

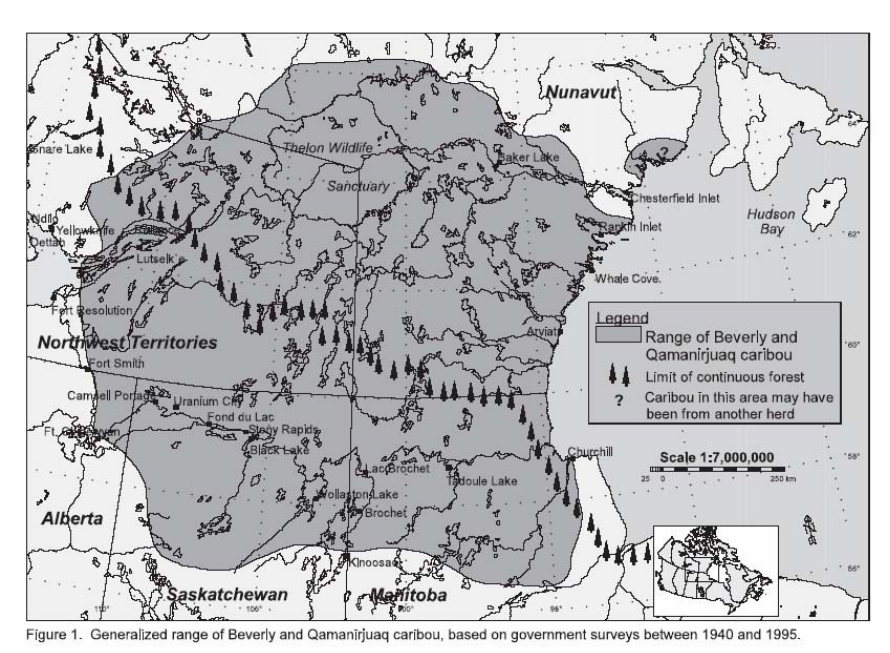


Figure 1. Generalized range of Beverly and Qamanirjuaq caribou, based on government surveys between 1940 and 1995.

(source: http://www.arctic-caribou.com/PDF/Text.pdf)

Ecozone(s): Taiga shield, Southern Arctic

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Northwest Territories, Nunavut, Manitoba, Alberta, Saskatchewan, Federal government

Measurement framework adopted: n/a

Information available as:
Raw data : yes, qualitative
Trend information: some, yes

Sources of Information

a.) Reports
Beverly and Qamanirjuaq Caribou Management Board
Beverly and Qamanirjuaq Caribou Management Board 1982-2002 : 20th anniversary report. Ottawa, ON, : Beverly and Qamanirjuaq Caribou Management Board, 2002, 60p.
Abstract: The Beverly and Qamanirjuaq Caribou Management Board (BQCMB) broke new ground when it became Canada's first co-management board for a major game species in 1982. It brought together aboriginal people and government wildlife managers from four different political jurisdictions -- the governments of Canada, Manitoba, Saskatchewan and the Northwest Territories -- to work toward the common goal of conserving two quite distinct caribou herds in northern Canada, the Beverly caribou herd and the Qamanirjuaq caribou herd.
Retrieved on 31 January , 2005 from the World Wide Web:
http://www.arctic-caribou.com/PDF/20th-annualreport.pdf

Beverly and Qamanirjuaq Caribou Management Board
Protecting Beverly and Qamanirjuaq caribou and caribou range : Part I : background information. Ottawa, ON, : Beverly and Qamanirjuaq Caribou Management Board, 1999, v, 19p.
Abstract: The Beverly and Qamanirjuaq Caribou Management Board (BQCMB or the "Board") was founded in 1982 to bring representatives of communities and governments together at regular meetings to ensure sustainable use of the Beverly and Qamanirjuaq herds of barren-ground caribou. The Board has evaluated the potential negative effects of some development activities on caribou and their habitat, but it needed a system to (a) access information

on past use of range by caribou, (b) evaluate the sensitivity of caribou and their habitats, and (c) assess the potential negative impacts of land use activities2 proposed for the range of Beverly and Qamanirjuaq caribou. Production of this report and a map atlas on computer disk (CD-ROM) are the first steps towards developing such a system. Retrieved on 31 January , 2005 from the World Wide Web
URL: http://www.arctic-caribou.com/cdrom/pdf/text.pdf

b.) Websites:
Beverly and Qamanirjuaq Caribou Range: Indicators of Change. Retrieved from the World Wide Web January 26, 2005
http://www.taiga.net/bq/indicators.html
http://www.arctic-caribou.com/index.html

c.) Organization(s) responsible and Contact person(s)
Daryll Hedman (represents Government of Manitoba)
Wildlife Manager
Manitoba Conservation
P.O. Box 28, 59 Elizabeth Dr.
Thompson MB R8N 1X4
(204) 677-6643 (office telephone)
(204) 677-6359 (fax)
e-mail: dhedman@gov.mb.ca

Title of Indicator Initiative / Program
Rat River biodiversity, cultural and Historical assessment

Initiative / Program objectives
1. document the traditional and historical use of the Rat River watershed
2. document the biodiversity of the Rat River watershed
3.

Year(s) of Initiative / Program: 1999

Indicator development process used: scientific knowledge & methods

Ecosystem type: northern river watershed

Indicators identified

Indicator	Years of data	Location of monitoring	Measurement
Plant biodiversity	1999	Summit Lake, Loon Lake, Horn Lake	Vegetation were surveyed at 3 different study sites where 5 different habitat types were present. 100 metre transect lines were set up in each habitat type and one metre squre quadrants were place every 20 metres.
Fish species	1999	Long Lake, Ogilvie Lake, Loon Lake, Horn Lake, Fish Creek, Rat River & 1 unnamed creek	A trap net and eight minnow traps were set up at random locations on the lake for 24 hours. An electroshocking backpack unit was used at some locations.
Mammal species	1999	Rat River watershed, Summit Lake, Loon Lake and Horn Lake	Literature review for all and trapping of small mammals such as shrews & voles at 3 study sites
Bird species	1999	Summit Lake, Loon Lake, Horn Lake	Each of the 5 habitat types at the 3 study sites was surveyed for 5 mornings and birds were inventoried

Geographic scope of indicators: Rat River watershed

Ecozone(s): taiga cordillera, taiga plains

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Gwich'in Settlement Area communities, Gwich'in Land Use Planning Board, Gwich'in Tribal Council, Northwest Territories

Measurement framework adopted: n/a

Information available as: raw data

Sources of Information

a.) Reports
Haszard, Shannon and Jennifer Shaw. 2000. *Rat River biodiversity, cultural and historical assessment*. [s.l.]: Gwich'in Renewable Resource Board. 78p.
Retrieved 3 February 2005 from the World Wide Web:

http://www.grrb.nt.ca/activefr.html

b.) Websites
Gwich’in Renewable Resource Board.
http://www.grrb.nt.ca/activefr.html

c.) Organization(s) responsible and Contact person(s)
Gwich'in Renewable Resource Board
P.O. Box 2240, 105 Distributor St.,
Inuvik, Northwest Territories, Canada
X0E-0T0
Phone: (867) 777-6600
Fax: (867) 777-6601
E-mail:
Office Manager:
barb.chalmers@grrb.nt.ca
(Also see "staff" for Board & Staff e-mails)

Title of Indicator Initiative / Program
Research and monitoring in National Parks in of the Western Arctic

Initiative / Program objectives
- Assess the ecological condition of national parks in the Inuvialuit Settlement namely Ivvavik, Aulavik and Tuktat nationals parks
- Meet the goals of the Inuvialuit Final Agreement to protect and preserve Arctic wildlife, environment and biological productivity through the application of conservation principles and practices.
- Provide information from research and monitoring activities to other organizations with resource management responsibilities

Year(s) of Initiative / Program: n/a

Indicator development process used: scientific knowledge & methods

Ecosystem type: coastal, freshwater, northern river basin, terrestrial

Indicators identified: see website for details (http://www.pc.gc.ca/docs/v-g/rs-rm2003/sec2/page1_E.asp)

Indicator	Years of Data	Location of Monitoring	Measurement
Wildlife cards: incidental wildlife observations	1986 - ongoing	Aulavik, Ivvavik and Tuktut Nogait national parks	presence, distribution, relative abundance of wildlife populations in Aulavik, Ivvavik and Tuktut Nogait national parks and surrounding regions
Bird checklist survey: scientific information about the distribution, abundance and breeding status of birds in the	1995 - ongoing	Aulavik, Ivvavik and Tuktut Nogait national parks	number of birds of each species, and evidence of breeding, is recorded on the checklists. Checklists are completed for a 24 hour or shorter period in a 10 x 10 km or smaller area.
Raptor survey	1952 - ongoing (Aulavik); 1972 - ongoing (Ivvavik); 1988, 1990, 1991 & 2001-2003 (Tuktut)	Aulavik, Ivvavik and Tuktut Nogait national parks	document the number of peregrine falcons and other species of raptors breeding in Aulavik, Ivvavik and Tuktut Nogait national parks.
Breeding bird surveys: changes in the abundance and distribution of bird populations	1999 - ongoing	Ivvavik National Park	Four transects, each with 12 stations, are surveyed. There are 2 transects at Margaret Lake and 2 transects at Sheep Creek. Birds are identified within a 50 m radius by sight and sound at each station. Observations at each station are made for 5 minutes.
Lemming monitoring: population change	1999 - 2001	Aulavik National Park	Lemming winter nests are counted using the plot and line transect survey methods.
Moose population classification	2000	Babbage River watershed, Ivvavik Park	Age and sex of moose, location and habitat type where moose were observed are recorded

Indicator	Years of Data	Location of Monitoring	Measurement
Muskoxen population classification and distribution	1973 - ongoing	Yukon North Slope, from the Alaska/Yukon border to the Blow River, including Ivvavik National Park	Muskoxen population sizes, and sex and age composition, are determined through aerial surveys conducted in the spring and summer. Muskoxen distribution and movements are determined by tracking muskoxen with satellite-radio collars and through aerial surveys
Muskoxen population census & distribution	1997, 2000	Tuktut Nogait National Park	Estimate the number and distribution of muskoxen within the boundaries of Tuktut Nogait National Park. Muskoxen are surveyed from a fixed-wing aircraft
Peary caribou monitoring: population dynamics, movement and health (abundance of parasites & diseases)	1972 - ongoing: Population estimates; 1982 - ongoing: classification surveys; 1994 - ongoing: winter range conditions; 1993 - ongoing: late winter body condition; 2000 - ongoing: parasite levels; 1982 - ongoing: summer range	Banks Island	Classification surveys are conducted by using a helicopter & caribou are observed with spotting scopes or binoculars and classified by age and sex. Productivity is estimated by counting the number of calves present per 100 two-year-old or older females. Over winter survival of calves is determined by counting the number of yearlings per 100 two-year-old or older females. Urine and fecal samples from caribou are collected and analysed to determine animal body condition. Satellite collars were placed on 10 Banks Island Peary caribou in 1999, and on 10 Low Arctic Peary caribou on Victoria Island in 2003, to track their distribution and movement. Fecal and fourth stomach samples are collected to determine the infection of caribou with parasites.

Indicator	Years of Data	Location of Monitoring	Measurement
Muskoxen population classification, dynamics, movements and health	1982 - ongoing: population survey; 1980s & 1999 - 2000: classification surveys; 1993 - 1989: winter range conditions; 1993-2001: later winter body condition; 1999- ongoing: levels of parasites	Banks Island	Muskoxen are counted from a fixed-wing aircraft with age and sex classification conducted in their high-density summer ranges. Productivity is estimated by counting the number of calves present per 100 2-year-old or older females. Recruitment of calves is determined by counting the number of yearlings present per 100 3-year-old or older females. Urine, snow urine and fecal samples from muskoxen are collected in low and high muskoxen density areas and analysed to determine animal body condition. Incidental observations of wolves are recorded. Fecal and fourth stomach samples are collected to determine infection of muskoxen by parasites. Data collected during commercial muskoxen harvests is being analysed to look at the change in pregnancy rates, body condition and size.
Caribou population characteristics, dynamics, health, distribution and movements	2000- ongoing: Productivity and age and sex compositions; 1986, 1987, 1992, 2000 and 2002: population estimates; 1978-various years & ongoing: productivity survey; 2001: parasites	Cape Bathurst and Bluenose-West caribou herds in the Northwest Territories and Nunavut	Productivity, recruitment of calves and age and sex composition surveys are conducted with radio telemetry equipped fixed-wing aircraft and a helicopter. Radio collars are used to track movements. Fecal samples were collected in 2001 and 2002 to determine infection levels of gastro-intestinal parasites. They were also collected in 2003 to determine infection levels in the Bluenose-West herd. Fall body condition was assessed in 2002 using various caribou body parts collected from hunters. Fourth stomach samples were collected from harvested animals during 2001 to determine the number and species of parasites present.

Indicator	Years of Data	Location of Monitoring	Measurement
Caribou population composition & dynamics, body condition, distribution and movements	1972 - ongoing: Population estimates; 1983 - ongoing: Calf mortality, calf:cow ratios and birth rate; 1970 - ongoing: seasonal range use	Porcupine caribou herd	photocensus of the Porcupine caribou herd is attempted every 3 years. A calving survey is conducted by locating satellite and radio collared caribou starting in late May. Composition counts are conducted every year in March to determine the calf:cow ratio Satellite collars are used to determine the seasonal distribution and movements of the herd.
Plant productivity changes	1997 - ongoing	Aulavik, Ivvavik and Tuktut Nogait national parks	use Advanced Very High Resolution Radiometer (AVHRR) satellite images to monitor landscapes and determine the Normalized Difference Vegetation Index (NDVI), which is recorded by the AVHRR satellite. Satellite images are taken daily from April 1 to October 21 each year
Pingo monitoring	2002	Tuktoyaktuk Pingo National Monument	Four PlantWatch plots and 5 photopoints were established close to Ibyuk and Split Pingos as a pilot project to monitor ecological change. Plot locations and vegetative composition were determined. Photos were taken from each photopoint.
Campsite use	1997 - ongoing	Firth River	Spring monitoring occurs before the first visitor trip. This monitoring is conducted to identify wildlife threats or concerns, such as wildlife carcasses near the site and active nest or den sites in the area. Fall monitoring is conducted to identify impacts resulting from human use of campsites during the summer. This involves comparing the composition and density of the vegetation at the campsite with the surrounding area, determining the presence and extent of bare soil, bank erosion, trails and root exposure caused by human use of the site, identifying damage to vegetation in the surrounding area and removing any waste or garbage left by people.

Indicator	Years of Data	Location of Monitoring	Measurement
Parks: human use	1994 - ongoing: Aulavik; 1989 - ongoing: Ivvavik; 1998 - ongoing: Tuktut	Aulavik, Ivvavik and Tuktut Nogait national parks	Information is collected on visitor, Parks Canada staff, researcher and student numbers in the park by dates of their visit and activities they conduct
Weather conditions	1995 - ongoing	Aulavik, Ivvavik and Tuktut Nogait national parks	Weather conditions at sites are recorded
Active layer monitoring	2000 - ongoing	Aulavik, Ivvavik	Permafrost probes are used to measure soil temperature at various depths
River water flow	1972 - 1994 & 1997 - ongoing: Firth River; 1998 - ongoing: Hornaday	Firth River in Ivvavik National Park and the Hornaday River in Tuktut Nogait National Park	Measures discharge and water levels
Coastal erosion: Beaufort Sea	1994, 1995, 1996, 1997, 1999, 2000 and 2003.	Beaufort Sea	Cliff and beach topography, near shore bathymetry, sediment samples and water levels are measured. Sediment grain size is measured using settling tubes and sedigraph or coulter counters. Sea temperature and storm surge monitoring is conducted at various locations along the Beaufort Sea coast.
Solid waste: Clean-up of fuel spill and landfill	2004 - ongoing	Komakuk Beach in Ivvavik national park	Samples are taken from the fuel spill monitoring wells. The landfill sites are monitored for vegetation growth, settlement, erosion, discoloration and odours.
Water quality	1999 - ongoing	Thomsen River in Aulavik National Park, the Firth River in Ivvavik National Park and the Hornaday River in Tuktut Nogait National Park	Water quality samples are analysed for physicals, nutrients, major cations, major anions, trace metals and organics.
Cultural resources	1995 - ongoing	Firth River, Ivvavik national park	The sites were photographed, and threats were identified, in 1999. Photographs and measurements of soil erosion are used to determine if the sites have changed. The cultural sites along the Firth River are monitored every 5 years. The next site assessment will be conducted in 2005.
Cultural resources	1987, 1997, 2000 and	Ivvavik coast	Initial surveys of cultural sites in Ivvavik National Park were

Indicator	Years of Data	Location of Monitoring	Measurement
	2002		conducted in 1987 and in 1997. Twelve of these sites were visited in 2000 to determine their condition and to develop methods for monitoring them. Photographs taken from established photopoints are used to determine changes.
Cultural resources	Nasogaluak: 1997, 1999, 2000, 2001 and 2002; M'Clure's Cache 1997, 2000; Head Hill: 1997, 1999, 2000, 2001 and 2002	Aulavik National Park	Photographs are taken and items measured to determine if they have been moved.

Geographic scope of indicators

Ecozone(s): Southern Arctic, Northern Arctic

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries:Federal government (Parks Canada), Yukon Territory, Nunavut, Inuvialuit Settlement Region

Measurement framework adopted

Information available as: raw and trend

Sources of Information:

a.) Reports
Canada. Parks Canada
Annual report of the research and monitoring in national parks of the western Arctic 2003. [s.l.], : Parks Canada, 2003, 80p.
This report is divided into two sections. Section 1 summarizes research projects that were conducted in 2003. Section 2 summarizes all ongoing monitoring projects. These monitoring projects are divided into seven categories: Wildlife, Habitat, Human Use, Climate Change, Solid Waste, Long Range Transport of Pesticides and Cultural Resources.
Summaries for each project include:
URL: http://www.emannorth.ca/reports/Parks2003_English.pdf
http://www.pc.gc.ca/docs/v-g/rs-rm2003/sec2/page1_E.asp

b.) Websites: http://www.pc.gc.ca/pn-np/yt/ivvavik/index_e.asp

c.) Organization(s) responsible and Contact person(s)
Parks Canada Agency. Western Arctic Field Unit
P.O. Box 1840, Inuvik, Northwest Territories
Canada X0E 0T0
Phone: **(867) 777-8800**

Fax: **(867) 777-8820**
Email: **Inuvik.info@pc.gc.ca**

Title of Indicator Initiative / Program
Terrestrial trophic dynamics in the Canadian Arctic (Swedish Tundra Northwest Expedition 1999)

Initiative / Program objectives
The Swedish Tundra Northwest Expedition to the Canadian Arctic in 1999 provided an opportunity to begin a synthesis of polar plant and animal communities with a view to understanding the factors that drive the dynamics of these ecosystems. (Krebs 2003, 828)

Year(s) of Initiative / Program: summer of 1999

Indicator development process used: scientific knowledge & methods. During the summer of 1999 the Swedish Tundra Northwest Expedition visited 17 sites across a 3000 mc long east-west transect from Baffin Island to the Yukon and a 2000 km long north-south transect from the Ungava Peninsula to Ellef Ringnes Islands.

Ecosystem type: Terrestrial

Indicators identified:
Data collections was done for the indicators at the following sites:
Ungava, Melville Peninsula, Somerset Island, Bathurst South, King William Island, Wollaston Peninsula, Amundson Gulf, Banks Island south, North Yukon, Cape Bathurst, banks Island north, Melville Island, Ellef Ringnes Island, Ellesmere Island south, Devon Island, Baffin Island (see map below).

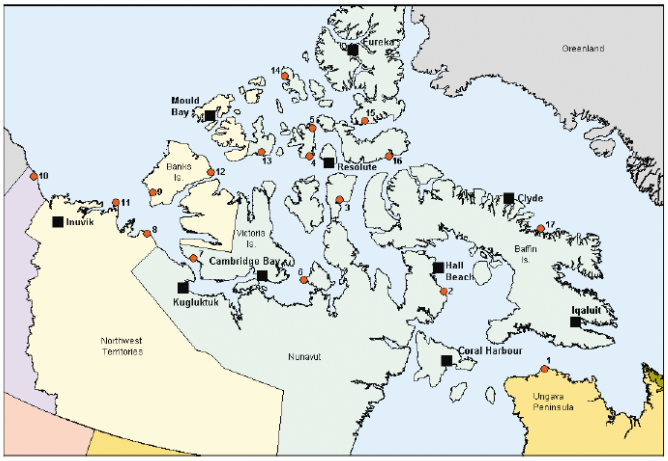
	Indicator	**Years of data**	**Location of monitoring**	**Measurement**
Biotic	Standing crop of vascular plant (corrected for phenology)	Summer 1999	NWT & Nunavut	Raw data
	Lemming & vole abundance	Summer 1999	NWT & Nunavut	Raw data
	Biomass of herbivores using faecal-pellet counts (muskoxen, caribou, arctic hare, geese & ptarmigan)	Summer 1999	NWT & Nunavut	Raw data
	Predator species census (foxes, raven, glaucous gull, rough-legged hawk, long-tailed jaeger, parasitic jaeger, ermine, snowy owl, peregrine falcon, gyrfalcom	Summer 1999	NWT & Nunavut	Raw data

Geographic scope of indicators

Ecozone(s): Northern and Southern Arctic

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Nunavut and Northwest Territories

Fig. 1. Map of the Canadian Arctic showing the locations of the sites visited by the Swedish Tundra Northwest Expedition of 199 (red circles) and existing weather stations (black squares). A total of 17 sites were visited but data from sites 1–5 are incomplete plants, so detailed data on all trophic levels are available from only 12 sites.



Measurement framework adopted: n/a

Information available as: raw data

Sources of Information

a.) Reports
Krebs, et al., **Charles J.**
"Terrestrial trophic dynamics in the the Canadian Arctic." *Canadian journal of zoology* 81 (5, 2003): 827-843.
Abstract: The Swedish Tundra Northwest Expedition of 1999 visited 17 sites throughout the Canadian Arctic. At 12 sites that were intensively sampled we estimated the standing crop of plants and the densities of herbivores and predators with an array of trapping, visual surveys, and faecal-pellet transects. We developed a trophic-balance model using ECOPATH to integrate these observations and determine the fate of primary and secondary production in these tundra ecosystems, which spanned an 8-fold range of standing crop of plants. We estimated that about 13% of net primary production was consumed by herbivores, while over 70% of small-herbivore production was estimated to flow to predators. Only 9% of large-herbivore production was consumed by predators. Organization of Canadian Arctic ecosystems appears to be more top-down than bottom-up. Net primary production does not seem to be herbivore-limited at any site. This is the first attempt to integrate trophic dynamics over the entire Canadian Arctic.
URL: http://article.pubs.nrc-cnrc.gc.ca/ppv/RPViewDoc?_handler_=HandleInitialGet&journal=cjz&volume=81&calyLang=eng&articleFile=z03-061.pdf

b.) Websites: http://www.zoology.ubc.ca/~krebs/tnw99.html
Includes link to Excel data file

c.) Organization(s) responsible and Contact person(s)
Charles Krebs
Professor Emeritus
krebs@zoology.ubc.ca

Title of Indicator Initiative / Program
Wapusk regional ecosystem satellite monitoring project

Initiative / Program objectives

Year(s) of Initiative / Program: 1998 - on-going

Indicator development process used: scientific knowledge & methods

Ecosystem type: terrestrial peatland and coastal salt marsh

Indicators identified

	Indicator	**Years of data**	**Location of monitoring**	**Measurement**
Biotic	Regional vegetation cover	1996 -	Wapusk National Park & surrounding Churchill Wildlife Management Area	Map (GIS) once every 5 years
	Fire frequency and extent	1973 –	Wapusk National Park & surrounding Churchill Wildlife Management Area	Annual monitoring

Geographic scope of indicators: Wapusk National Park and the surrounding Churchill Wildlife Management Area in Manitoba

Ecozone(s):

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Northern Manitoba, Wapusk National Park, Churchill Wildlife Management Area

Measurement framework adopted: n/a

Data sources: (e.g. scientific, statistical, traditional knowledge, etc.): Scientific-Landsat satellite imagery (1973 – 2001); ground based measures of vegetation cover (n=1200). Statistical analysis of regional vegetation dynamics and fire extent and frequency.

Information available as: Raw vegetation map and fire cover data available. Analysis publication in preparation.

Sources of Information

a.) Reports
Brook, R.K. and N.C. Kenkel. 2002. "A multivariate approach to vegetation mapping of Manitoba's Hudson Bay Lowlands." International Journal of Remote Sensing 23 (21): 4761-4776.

Brook, R.K., N.C. Kenkel and T.M. Naughten. 2001. "Vegetation mapping in Wapusk National Park: a view from outerspace." Research Links 9 (1): 8, 14-15.

Richardson, E.S. and R.K. Brook. 2001. "Arctic and red fox den site selection in Churchill, Manitoba." Research links 9 (1): 19.

Brook, R.K., B. Thompson, B. Sparling and D. O'Brien. 2001. Wapusk National Park ecological integrity statement vegetation map. Prepared for Wapusk National Park.

Brook, R.K. and N.C. Kenkel. 2000. A multivariate approach to land cover mapping in the Hudson Bay Lowlands, Manitoba. Proceeding of the Sixth Circumpolar Symposium on Remote Sensing of Polar Environments, June 12-14, Yellowknife, NWT.

Gadallah, F., F. Csillag and R.K. Brook. 2000. Historical vegetation mapping using unsupervised classification of Landsat imagery and ancillary data. Proceedings of the Ecological Society of America Converence, Snowbird Utah, August 6-10.

Brook, R.K. 1999. Biological inventory of Marantz Lake Kame. Prepared for Wat'chee Lodge.

b.) Organization(s) responsible and Contact person(s)
Raw data available through ryan brook: ryan_brook@umanitoba.ca

Ryan K. Brook
Department of Environment and Geography
University of Manitoba
Winnipeg, Manitoba R3T 2N2
Canada
Office: 1 – 204 – 638-4183
201 Macleod Ave. W. Dauphin Manitoba
R7N 0H4
Cell: 1-204-479-9147
Fax: 1-204-275-3147

Title of Indicator Initiative / Program
West Kitikmeot Slave study (WKSS)

Initiative / Program objectives
"The goal was to collect and provide information on the effects of the development in the West Kitikmeot / Slave area to its Partners to their use in making informed decisions." (p 1)
- collection of environmental and socioeconomic information
- contribute to a baseline for assessing and mitigating cumulative effects of development

Year(s) of Initiative / Program: 1994/95- 2001

Indicator development process used: local, traditional knowledge and scientific knowledge & methods. The West Kitikmeot Slave Study Society was established and included nine founding Partner organizations representing governments, Inuit and Dene communities, environmental organizations and the mining industry. There was a Traditional Knowledge Steering Committee and a Project Steering Committee

Ecosystem type: freshwater, terrestrial, ocean

Indicators identified:
Note about the indicators identified**:** The indicators are derived from project studies that are summarized in the "Final report: West Kitikmeot Slave Study Area"

Indicator	Years of data	Location of monitoring	Measurement
Caribou calving ground location: factors effecting location changes	1999 - 2001	Bathurst Caribou herd	Analysis of the food value & protein content of plants eaten by caribou at the calving ground. Possible impacts of global climate change were assessed based on satellite information.
Caribou: TEK	n/a	Umingmaktuk, Kingauk, Hanigayak, Cambridgge Bay and Kugluktuk	Information from elders recorded on audio and video tape
Caribou: TEK on migration & state of caribou habitat	1917 - 1998	Dogrib Elders	Oral narratives were recorded and locations identified were mapped.
Caribou: seasonal movements of the Bathurst herd	1998 - 2001	Bathurst Caribou herd	Caribou were collared with satellite transmitters
Caribou: behaviour around mine sites	1996 - 1998 (?)	n/a	Researchers & remote cameras were used to observe caribou behaviour around the mine sites
Wolf habitat use for denning	1998 - ongoing (?)	Lac de Gras / Contwoyto Lake area	Dens were mapped and wolves collared to track their movements as well as determine if they returned to natal denning areas
Wolverine ecology	1996 - 1999	Kugluktuk and Bathurst Inlet	Collars were used to determine range and physical characteristics of captured and killed wolverine were documented.
Grizzly bear population ecology	1995 - 1999	Lac de Gras / Contwoyto Lake area	Satellite collars were used to track bear movements, habitat selection and dens
Birds: health (TEK)	n/a	Kache Tue study region	Indicators identified by elders based on narratives
Fish: health (TEK)	n/a	Kache Tue study region	Indicators identified by elders based on narratives

Indicator	Years of data	Location of monitoring	Measurement
Caribou: health (TEK)	n/a	Kache Tue study region	Indicators identified by elders based on narratives
Furbreaers: health	n/a	Kache Tue study region	Indicators identified by elders based on narratives
Water quality	1997 - 2000	Baton Lake, Great Slave Lake, Lac de Gras	Water quality at 3 diamond drilling sites was measured for water cloudiness and sediment samples were analyzed for changes in chemistry and particle size.

Geographic scope of indicators

Ecozone(s): Southern Arctic, Taiga Shield

Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Nunavut and Northwest Territories, Dogrib Treaty 11 Council, Lutsel K'e Dene First Nation, Metis Nation of the Northwest Territories, Federal Government

Measurement framework adopted: n/a

Information available as: qualitative and scientific data

Sources of Information

a.) Reports

West Kitikmeot Slave Study Society. *Final report: West Kitikmeot Slave Study: include annual report 2000 – 2001.* Yellowknife: The Society, 2001. 87p.

20 reports are listed at the website at: http://www.wkss.nt.ca/HTML/08_ProjectsReports/08_index.htm

West Kitikmeot Slave study: final report. Yellowknife: The Society, 2001.
Note: includes Annual Report 2000-2001.
http://www.wkss.nt.ca/HTML/08_ProjectsReports/08_final/08_finalreport.htm

State of Knowledge Report
WKSS Research Framework

Traditional Knowledge Research
Habitat
Traditional Ecological Knowledge Research in the Kache Kue Study Region
Habitat of Dogrib Traditional Territory: Place Names as Indicators of Bio-geographical Knowledge
Community Based Monitoring
Traditional Knowledge Study on Community Health
A Community Based Monitoring System in the Slave Geological Province
Final Report: Community Based Monitoring
Caribou
Traditional knowledge on the Relationship between Caribou Migration Patterns and the state of caribou habitat
Tuktu and Nogak Project - Inuit Knowledge about Wildlife in Bathurst Inlet: Focus on Caribou and Calving Areas

Scientific Research
Habitat
Habitat/Vegetation Classification for the West Kitikmeot/Slave Study Region
Esker Habitat Studies in the Slave Geological Province
--- Esker Habitat Characteristics and Traditional Use Study in the Slave Geological Province

Water
Investigation of Aquatic Impacts of On-Ice Exploratory Diamond Drilling
Reading Water Quality Record in West Kitikmeot/Slave Sediment
Caribou
Bathurst Caribou Calving Ground Studies
--- Influence Of Nutrition And Human Activity On Calving Ground Location
--- Prevalence and Intensity of Gastro-intestinal Nematode Parasitism in the Bathurst Caribou Herd, 1998-99.
Seasonal Movements of the Bathurst Caribou Herd
Summer Behaviour of Bathurst Caribou Herd
--- Summer Behaviour of Bathurst Caribou at Mine Sites and Response of Caribou to Fencing and Plastic Deflectors
--- Effect of Gravel Road and Tailing Pond Dust on Tundra Plant Communities near Lupin Mine, NWT
Grizzly Bear
Population Ecology of Grizzly Bears in the Slave Geological Province
--- Spatial Organization and Habitat Selection Patterns of Barren ground Grizzly Bears
--- Grizzly Bear (Ursus Arctos) Studies in the Northwest Territories: Nutritional Component
Wolverine
Wolverine Ecology, Distribution and Productivity in a Tundra Environment
Wolves
Esker Habitat Studies in the Slave Geological Province
--- Analysis of Esker Use by Wolves Denning in the Central Arctic, NWT

b.) Websites: http://www.wkss.nt.ca/index.htm

c.) Organization(s) responsible and Contact person(s)
West Kitikmeot Slave Study Society

Title of Indicator Initiative / Program
Yukon State of the Environment Report

Initiative / Program objectives

provides early warning and analysis of potential problems for the environment;
allows the public to monitor progress towards the achievement of the objectives of the Environment Act;
provides baseline information for environmental planning, assessment and regulation. [website http://www.environmentyukon.gov.yk.ca/soe/soe.shtml]

Year(s) of Initiative / Program: 1995 – ongoing.

Indicator development process used: local, traditional knowledge and scientific knowledge & methods

Ecosystem type: wetland and forest

Indicators identified

Indicator	Years of data	Location of monitoring	Measurement
Chinook, chum and coho salmon run size and returns for spawning	1980 - 2000 (upper Yukon); 1971 - 1999: Porcupine River	Yukon River drainage	
Birds: population	1982 - 2002 (gyrfalcon); 2000 – 2001 (owl callings)	Yukon Territory	Based on limited surveys completed there are no significant trends in waterfowl numbers; gyrfalcon population dynamics; number of owl callings noted by BC-Yukon Nocturnal Owl Survey
Furbearing mammals: population	1998 - 2002	Yukon Territory	Population trends & trapping interest
Caribou: population, range (distribution)	1920 - 2002 (Fortymile herd); 1860 - 2002: Chisana herd	Yukon Territory	Population estimates
Moose: population	1989 - 2002 (Dawson E. Survey; 1987 - 2001: North Canol survey	Dawson East survey area and North Canol survey area	Population estimates
Grizzly bears: population	n/a	Yukon Territory	Protection measures
Thinhorn sheep: population, no of lambs per 100 nursery sheep	n/a (population); 1973 - 2001(lambs per 100 nursery sheep	Yukon Territory	Population estimates
Species at risk under COSEWIC	2000	Yukon Territory	List of species at risk under COSEWIC in the Yukon
Species at risk: Pergrine Falcon	1972 - 2000	Yukon Territory	Number of pairs producing young / year
Wetland inventory	1973 - ongoing	Yukon Territory	surveys

Indicator	Years of data	Location of monitoring	Measurement
Forests: forest fire statistics, infestation, species inventory	1946 - 2001 (forest fires)	Yukon Territory	No. of fires / year
Caribou: available forage calving grounds	1985 - 2001	Porcupine caribou herd	NDVI is measured on June 21 each year
Ambient air quality: carbon monoxide, nitrogen oxides, ground level ozone and particulate matter monitoring	1984 - 2001 (CO2 levels in Whitehorse)	Yukon Territory	
Climate change: greenhouse gas emissions by sector / year; temperature and precipitation monitoring; Yukon River break-up dates and ice thickness at Dawson City; mean annual flood trend distribution; snowpatch melt-out; relative amount of green plant material within the Porcupine Caribou calving grounds; spruce bark beetle emergence	1990 - 2000 (GHG emissions); 1920 - 2000 (Mayo summer precipitation; 1920 - 2000 (Mayo summer mean monthly temperatures)	Yukon Territory	
Yukon River break-up dates & ice thickness at Dawson City	1896 - 1996	Yukon River at Dawson City	
Water: drinking water quality (surface and ground); streamflow regimes	1940 – 2000 (mean annual flood trendlines)	Yukon Territory	On-going monitoring of drinking water quality & on infectious and communicable diseases; monthly data showing annual flow variation for each river and peak flows
Freshwater fish harvesting: licenses sold, number of fish caught, number of fish stocked	1989 - 2002	Yukon Territory	
Ptarmigan harvest	1995 - 2001	Yukon Territory	Number of ptarmigan harvested / year
Furbearing mammals: species harvest and average pelt prices	1997 - 2002	Yukon Territory	
Caribou: licensed caribou harvest	1999 - 2002	Yukon Territory	no. of kills / year
Moose: licensed moose harvest	1999 - 2002	Yukon Territory	no. of kills / year
Grizzly bears: licensed harvest and control kills	1999 - 2002	Yukon Territory	no. of kills / year
Thinhorn sheep: licensed sheep harvest no. of kills / year	1980 - 2000	Yukon	no. of kills / year
Hunting licences sold	1978 - 2002	Yukon Territory	
Water: annual allocated water use by sector	n/a	Yukon Territory	
Protected areas: location and size and IUCN category	n/a	Yukon Territory	

Indicator	Years of data	Location of monitoring	Measurement
Waste management: metric tonnes of waste diverted	n/a	Yukon Territory	
Mining: number of active placer mines; percent of Yukon land base covered by mining claims	1995 - 2002	Yukon Territory	
Forestry: cubic metres of forest harvest products; area of forested land harvested and planted / year	1993 - 2002 (forest harvest products); 1975 - 1999 (forested land harvested & planted)	Yukon Territory	
Agriculture: number and area of farms; acres land in production 1996-2001	1991 - 2001 (number & area of farms)1996 - 2001 (land in production)	Yukon Territory	
Tourism: annual border crossings; top reasons for visiting the Yukon; top activities while in the Yukon	1994 - 2002 (annual border crossings)	Yukon Territory	
Oil & gas: $ revenues and % GDP / year; federal government-issues licences	1989 - 2001 (revenues & & GDP)	Yukon Territory	
Wildlife values: participation in Wildlife Viewing Program	1998 - 2002	Yukon Territory	Number of participants / year

Geographic scope of indicators

Ecozone(s): Boreal cordillera, taiga cordillera
Jurisdictional / Administrative unit(s) operating within ecosystem boundaries: Yukon Territory

Measurement framework adopted: n/a
Information available as: trend

Sources of Information
a.) Reports
Yukon Territory -Yukon Environment
Yukon state of the environment report 2002. Whitehorse, YT, CA : Government of Yukon, 2002, 62p.
Abstract: This report provides a portrait of the Yukon environment as well as baseline data, emerging environmental problems and cumulative effects.
URL: http://www.environmentyukon.gov.yk.ca/soe/content/2002soe.pdf

b.) Websites: http://www.environmentyukon.gov.yk.ca/soe/soe.shtml

c.) Organization(s) responsible and Contact person(s)
Yukon State of the Environment Reporting
Policy & Planning Branch V-2
Phone: (867) 667-5634
Toll free (in Yukon): (1-800) 661-0408, local 5634
Fax: (867) 393-6213
SOE@gov.yk.ca

7. Databases and Web Sites Searched

Databases searched:

SD-Cite (IISD's research library database)
IISD Compendium of Indicator Initiatives
AMICUS (National Library database)
CISTI (Canadian Institute for Scientific and Technical Information)
Ingenta (index of peer-reviewed journals and professional publications)
Northern Climate Exchange database of climate change information sources for Northern Canada: http://yukon.taiga.net/infosources/
Northwest Territories RWED library database: http://www.gov.nt.ca/RWED/library/index.htm
PolarInfo: http://www.library.ualberta.ca/databases/databaseinfo/index.cfm?ID=284
Nunavut Environmental Database: http://136.159.147.171/scripts/minisa.dll?HOME
Nunavut Wildlife Resource Centres Coalition: http://www.nwrcc.ca/search/search.php?search=6
University of Northern British Columbia Geoffrey R. Weller library: http://library.unbc.ca/
Parks Canada library: http://pch-geoweb.pch.gc.ca:8000/
EMAN library & website: http://www.eman-rese.ca/eman/reports/intro.html
Arctic Science and Technology Information Systems (ASTIS) database: http://www.aina.ucalgary.ca/astis/ (maybe go back to this one & do advanced search)
University of Manitoba library database
WAVES – DFO library database
Memorial University Labrador Institute library database: http://www.mun.ca/labradorinstitute/library.php

Web Sites searched:

Ajunnginiq Centre: http://www.naho.ca/inuit/english/our_centre.php
Alaska Geobotany Center: http://www.geobotany.uaf.edu/
Alberta Environment: http://www3.gov.ab.ca/env/index.html
Arctic Borderlands Ecological Co-op
Arctic Change:
Arctic Climate Impact Assessment (ACIA): http://www.acia.uaf.edu/
Arctic Council
Arctic Council activities: http://www.arctic-council.org/en/main/infopage/5/#amap
Arctic Is: http://www.thearctic.is/
Arctic Monitoring and Assessment Programme (AMAP): http://www.amap.no/
Aurora Research Institute: http://www.nwtresearch.com/ (library database not on-line)
Beverly and Qamanirjuaq Caribou Management Board: http://www.arctic-caribou.com/
British Columbia Forest Science Program
CAFF (Conservation of Arctic Flora and Fauna): http://www.caff.is/
Canada / MAB Northern Sciences Network: http://www.eman-rese.ca/partners/mab/mab.html

Canadian Environmental Assessment Agency: http://www.ceaa-acee.gc.ca/index_e.htm
Canadian Taiga & Tundra Experiment (CANTTEX):
http://www.taiga.net/canttex/index.html
Canadian Wildlife Service:
CARC
C-CIARN North: http://www.taiga.net/c-ciarn-north/projects.html
Caribou Commons project: http://www.cariboucommons.com/
Churchill Northern Studies Centre: http://www.churchillmb.net/~cnsc/index.htm
Council of Yukon First Nations: http://www.cyfn.ca/
CPAWS Yukon:
EMAN-North
EMAN-North activities: http://www.emannorth.ca/activities.cfm
Environment Canada
Environment Canada Pacific & Yukon Indicators:
http://www.ecoinfo.ec.gc.ca/env_ind/indicators_e.cfm (indicators are mainly from British Columbia)
Environment Canada ecosystems: http://www.pnr-rpn.ec.gc.ca/nature/ecosystems/index.en.html
Finnish Environment Institute
Fisheries Joint Management Committee: http://www.fjmc.ca/
Gwich'in Renewable Resources Board: http://www.grrb.nt.ca/index.html
Human Dimensions of the Arctic system:
Indian and Northern Affairs Canada
Inuit Circumpolar Conference
Inuit Tapirit Kanatami
Inuvialuit Cultural Resource Centre (couldn't find website using Google)
Inuvialuit Regional Corporation: http://www.irc.inuvialuit.com/inuvialuit/irc-website.nsf/frmHome?OpenForm
ITEX: website blocked on Wed. January 19, 2005
Kativik Regional Government: http://www.krg.ca/en/index.htm
Kluane monitoring project
Mackenzie River Basin Board: http://www.mrbb.ca/default.asp
Nordic Council
Northwest Territories (government)
Nunavut (government)
Nunavut Research Institute: http://pooka.nunanet.com/~research/Publications.htm
Parks Canada
Prince of Wales Northern Heritage Centre
Rangifer.net : http://www.rangifer.net/rangifer/monitoring/index.cfm
Sahtu Renewable Resources Board: http://www.srrb.nt.ca/index.html
Standing Committee of Parliamentarians of the Arctic Region
Taiga.net
United Nations Environment Programme GRID Arendal
University of Alaska. http://nrm.salrm.uaf.edu/~jfox/ForSciDept/ResHigh.html

Note: programs near Fairbanks. No relationship to Canada apparent.
University of the Arctic: http://www.uarctic.org/index.html
Yukon College Northern Research Institute:
http://yukoncollege.yk.ca/programs/nri/index.html
Yukon Conservation Society: http://www.yukonconservation.org/
Yukon Science Institute: http://www.taiga.net/ysi/ipyprojects.html
West Kitikeot/Slave Study Society
World Wildlife Fund Canada
University of the Arctic
Y2Y: http://www.y2y.net/science/grants/sciencesymposium.asp
Yukon College. Northern Research Institute:
http://www.yukoncollege.yk.ca/programs/nri/
Yukon River Inter-Tribal Watershed Council: http://www.yritwc.com/menu.htm (should interview)
Yukon Science Institute:
Yukon Territory (government)

References

MacDonald Environmental Services Ltd. 1994. *A discussion paper on the development of ecosystem maintenance indicators for the transboundary river systems within the Mackenzie River Basin: Slave, Liard, and Peel Rivers, prepared for Water Resources Division….Indian and Northern Affairs Canada*. Ladysmith, BC: MacDonald Environmental Services. 109p.

Wiersma, **Yolanda F.** "Environmental benchmarks vs. ecological benchmarks for assessment and monitoring in Canada: is there a difference*?" Environmental monitoring and assessment* 100 (1-3, 2005): 1-9.

Appendix 1: List of Interviewees

Interviews for the NEI Indicator Inventory Project

Name	Organization	Position	Contact Info	Date of Interview
Barber, David	U of Manitoba ArcticNet Theme 3	Associate Dean (Research), Faculty of Environment, Director, Centre for Earth Observation Science	204-474-6981 dbarber@Ms.UManitoba.ca	Feb. 3, 2005
Baydack, Rick	Faculty of Environment, Earth, and Resources University of Manitoba	Associate Dean	204-474-6776 baydack@cc.umanitoba.ca	Mar. 3, 2005
Bello, Richard *	Churchill Northern Study Centre and U of York	Vice Chair of the Board of Directors, CNSC	bello@yorku.ca	Feb. 7, 2005
Buckland, Barbara *	CSIN and NIRO, Environment Canada		Barb.Buckland@ec.gc.ca	Feb. 2-3, 2005
Christensen, Villy *	Fisheries Centre, Univ. of British Columbia	Associate professor	v.christensen@fisheries.ubc.ca	Feb. 8, 2005
Eamer, Claire *	Northern Research Institute, Yukon	Yukon Coordinator Canadian Climate Impacts and Adaptation Research Network - North (C-CIARN North)	867-668-8862 ceamer@yukoncollege.yk.ca	Feb. 8, 2005
Eamer, Joan (was interviewed with Wakelyn, Leslie)	EMAN-NORTH Environment Canada Northern Conservation Division Pacific & Yukon Region, Whitehorse	EMAN-North Coordinator; Head, Biodiversity and Ecosystem Science Section	867-667-6963 Joan.Eamer@ec.gc.ca	Feb. 4, 2005
Fishback, LeeAnn *	Churchill Northern Study Centre	Scientific Coordinator	807-468-4611 fishback@voyageur.ca	Feb. 8, 2005
Gill, Mike	Arctic Borderlands Ecological Knowledge Co-op		867-393-6760 Mike.Gill@ec.gc.ca	Feb. 4, 2005

Name	Organization	Position	Contact Info	Date of Interview
King, Leslie	Environment, Earth, & Resources University of Manitoba ArcticNet	Dean, Environmental Faculty	204-474-7248; 204-471-2438 lking@cc.umanitoba.ca	Feb. 9, 2005
McBean, Gordon	ArcticNet U of Waterloo	Leader, Theme 4	519-661-4274 gmcbean@eng.uwo.ca	Mar. 3, 2005
Papakyriakou, Tim	Environment, Earth, & Resources University of Manitoba		204-452-4875 papakyri@Ms.UManitoba.CA	Feb. 10, 2005
Rautio, Milla	ArcticNet Theme 2 Department of Biology, Laval University	Science Coordinator	418-656-7106 Milla.Rautio@bio.ulaval.ca	Feb. 14, 2005
Russell, Don *	CARMA Network Pacific and Yukon Region Canadian Wildlife Service, Environmental Conservation Branch	CARMA Network Coordinator	Don.Russell@ec.gc.ca	Jan. 27, 2005
Shirley, Jamal	Nunavut Research Institute	Manager, Research Design and Policy Development	867-979-7290 jshirley@nac.nu.ca	Feb. 3, 2005
Telmer, Kevin *	School of Earth and Ocean Sciences University of Victoria Universidade de Campinas, Brasil	FAPESP Visiting Scholar	19-3788-4572 ktelmer@uvic.ca	Mar. 7, 2005
Wakelyn, Leslie (was interviewed with Eamer, Joan)	EMAN-NORTH Canadian Wildlife Service, Environment Canada, Yellowknife	EMAN-North Coordinator	867-669-4786 Leslie.Wakelyn@ec.gc.ca	Feb. 4, 2005

*Responded, but did not provide interview

Appendix 2: Summary of Interviews

BARBER, DAVID (ArcticNet; U of Manitoba)

Team Leader, Theme 3 of ArcticNet: Land-Ocean Interactions in Sub-Arctic Hudson Bay Sea-ice studies as a part of climate change studies on the Arctic; observations and data collection; not using or processing indicators per se.

Expectation from indicators:
What would be the useful indicators in the process of summarizing what is going on in the broad sense in climate change in the North.
Scientific bias: Indicators should help understand, not manage the system.

- Indicators need to be statistically reliable and should indicate the rate of change
- The process that underpins indicators is more important from his research perspective than the specific indicators themselves
- How can we define reproducible indices and using them in combination with other data/information
- Different variables that combine an index need to be measured regularly to understand stochastic processes
- Individual thermodynamic variables that are regularly measured now could be aggregated into system indicators (consistency in measurement based on space measures)

Variables that could help define ecosystem indicators:

- Sea-ice parameters in general
- Primary production at the base of the ice (i.e. algic growth) and secondary production (melt of sea-ice) combined: good ecosystem health indicator

Lessons learned: (based on 24 years of research)

- Need for a baseline that in most cases does not exist
- More emphasis on ability to monitor individual variables over time in order to better understand trends and natural variability of observed data
- Need for an observational system/network that is capable of establishing reliable historic data (historical observation is very patchy)
- The Arctic is a highly dynamic space where measurement/monitoring needed for reasonably long time and with reasonably high density (present data are patchy and low density because of costs of mooring stations and instrumentation)
- Observation science is increasingly left to universities (scaling federal programs back) but they are doing more project related studies

Integration:
Need for integration of arctic climate change observation and data in order to interpret information for the North as an ecosystem and its changes

- No international standardization of monitoring programs
- No standardization of monitoring methodology
- Feasibility study: Arctic Observing Network under the auspices of the US National Academy of Science: Collects information on what should be measured and how to integrate observation under a single umbrella, involving different agencies, countries and

canvassing also Europe; propose a network and submit for funding decision to the US National Science Foundation

Interdisciplinary integration:

On Northern ecosystem level: A necessity for explaining the system.

- ArcticNet integrates programs across disciplines *Check SEARC (US)*
- Climate driven changes
- Environmental changes
- Last five years: breaking barrier in integrated research

Expectations from inventory project:

- Find common features of indicators
- Help define indicator criteria in order to develop reproducible, stable indicators with the capacity to explain statistical variations
- Help identify most general clusters of grouping indicators
- Overcome fragmentation by scientific, management and policy-making needs
    - Gather people together from scientists, managers, policy makers and local groups to brainstorm what would be the best grouping

BAYDACK, RICK (U of Manitoba)

Work on animal behavior (field work in the North) how human interference change animal behavior, particularly aggression (research among polar bears).

Cautioned against using these observations as ecosystem indicators as they are more indications of the impact of human interference – human-nature interaction indicators.

He finds it difficult to define high level ecosystem indicators, he considers them silver bullets. He and his team are still sorting out answers on aggregation.

In another, not North related ecosystem work he and his colleagues have defined technical indicators for performance measures, aimed at wildlife managers, at different ecological levels:

Landscape
Ecosystem
Species
Genetics

He called our attention to the forest industry where indicators for biodiversity have been defined.

BUCKLAND, BARBARA (EC NIRO)

We developed an overview report and annotated inventory of existing indicator and reporting initiatives in Canada to support an indicatory and reporting strategy. This effort also included a set of interviews with indicator and reporting practitioners. Our inventory was not strong on municipal or northern initiatives, so I am glad you are doing one for the north. In the end the overview report was a bit long, but we were planning on a much shorter strategy document as the top layer. Attached are the two reports as they will soon appear on the internet (ignore the titles they will be changing). The strategy is still in development. Because of the variability in the indicator and reporting initiatives we reported on, we found it very difficult to standardize the annotations. What we ended up with mostly, were brief descriptions of major initiatives and an attempt to list more specific information on individual indicators in a database. I would suggest your approach of developing a defined taxonomy is the better way to go, as it will help you summarize what you find in a more comprehensive manner.

The second similar process we engaged in was the updating of the IISD compendium entries. We used the annotated inventory described above as a starting point and then redefined what fields we would attempt to populate. It was difficult to determine which fields would be crucial and we took some time defining the final list. When Dave Piechota then ploughed ahead to fill in the fields, those dealing with program objectives or goals, committee and public involvement were harder to fill. To set priorities, we found it useful to ask why we would need certain types of information - for what purpose would we use the information. The information with the most urgent and practical applications were deemed crucial.

The taxonomy you have defined is very similar to the current compendium fields and I think that is a good thing. If you could align the two lists even more, the northern inventory of initiatives could be added to the compendium very easily. We have further developed our indicator inventory and hope to align it with the compendium, so that both indicator and initiative information can be available, but not duplicated. Of course, the NEI would like to have both the anecdotal information on the initiatives and the detailed information on the specific indicators and/or monitoring data. Time always dictates what can be done on each. I think the annotated bibliographic records are a good way to go, but I would confirm that the information most needed is being listed in these records. Does NEI most need to know who is measuring and reporting on what where? What degree of detail concerning the what and where is needed for this overview analysis and what degree is practical within the timeframe? Is it most important to identify those producing trend information? Do they also need to know if the activity is fulfilling a commitment to some agreement or larger program? Will there be an effort put into maintaining/expanding this inventory, perhaps through the inclusion of the gathered information into the IISD compendium and NIRO's indicator inventory or some northern focused equivalent?

EAMER, JOAN and WAKELYN, LESLIE (EMAN-N)

Focus is on monitoring activities, not on indicators

- improve and facilitate monitoring activities and conditions, provide venue for exchange

Next natural step: Create indicators

- Natural because monitoring provides background for indicators, establishes datasets and time trends
- Missing for next step to be reality: Money; human resources; will power
- Needs also framework

EMAN-N has no specific framework, it is more a communicating structure

- NCP has a framework and provides time trends for developing elements into indicators to be used to track progress and change
- EMAN-N is used primarily for management reasons (waterfowl monitoring) but provides trend information too: climate and environment (after the fact and on the ground approach) → could be considered ecosystem health indicators
- Forum for talking to individual people; the supporting role of the web site
- Can provide information on where plans are to use indicators:

Check out: Nunavut and NWT governments, plans for SOE reports

<u>Lessons learned</u>: (Based on 10 years of involvement)
EMAN-N has been a real challenge, running on the good will and enthusiasm of a few people.
Most important achievement, success:

- Venue for status and trend reporting
- Networking and exchanging experience and expertise
    - Helps identify needs
    - Info center on web site
- Methods manuals

It proved to be successful when federal people are in regional offices and co-management boards

- provides consistency for the right way to do monitoring
- makes work compatible with that of others

<u>Difficulties/weaknesses:</u>

- Inability to do much due to scarce resources and inconsistent government support
- Organizational structure, difficult to manage board
- Build on existing projects
- Start work on developing indicators
- Beyond participants control: No institutionalized structures; participating institutions are there only because of individual commitments
- Needs more recognition and importance attached to it by federal and territorial governments (more support is needed)
    - Should be part of workplans
    - positive example: Parks Canada
    - needs local buy-in, don't perceive as federally driven exercise on top of local issues

National EMAN is much ahead in standardization efforts and/or in use of agreed core variables

Expectation for present inventory:
Provide feedback for planned overview of monitoring

- Logically that should have come first: first short experiment in 2002
- Monitoring overview to continue and complement indicator inventory: What is solid
- Help how to use existing info center materials from the point of view of indicator framework development and from publication's purposes (what people need)

GILL, MIKE (Arctic Borderland Ecological Knowledge Co-op)

Lots of ecological indicators exist for the North and lots of data, but it is arguable how relevant they are from the particular perspective of ecosystems

- E.g. in Yukon: The observation of large mammals is done solely for harvesting purposes
- There is no across-jurisdictional boundary-type of general information
    - Differently collected data, different GIS formats, not applicable for common data base
- Data sets are not brought out as indicator products or outputs
- No synthesis points are provided, except: Parks Canada

Contact: David Henry

Strategic assessment done:

- What kind of information is important and/or available
- Activities are meeting the goals of the program
- Reasonable coverage of physical and biological variables
- Go slowly and don't let it collapse by fast inclusion of different type of info
    - Reluctance to include human health indicators
- The Co-op has fairly distinct goals with indicators: What should be measured and what data are already there
- Let's get the stories: Next step is "theme" reporting

<u>New indicators planned</u>:

- Add new regional info for North Yukon
- Expand geographic coverage for temperature and precipitation info
    - For snow density and depth (no snow cover observation yet)
    - For sea-ice cover
- Add stressor indicators (e.g. beluga monitoring by aircraft overflights)

<u>International outlook</u>:

Cooperation with Alaskan researchers (US Fish and Wildlife Service) to establish time trend sets

- Co-op benefits (better funding, more work can be done)
- US NSF uses Co-op as a model for community involved research (applicability to oil sand area)

<u>Lessons learned</u>: (based on 10 years of involvement)

Why successful?

- Partly because of good timing: There was much frustration between researchers and communities what and why measure
- Model truly involves communities and aboriginals who own the monitoring
- Good process for ongoing dialogue and builds trust
    - It is kept slow and simple
    - Lots of materials are going back to the community
    - Value of information is better understood (can use more variables)
- Structure: makes adjustment over time possible
- Content: indicators are at the foundation of the Co-op

    - Allows rich discussions on the relationship between data and indicators
    - Strong datasets (good density and length of records), in particular:
        - Yukon river ice breakup
        - Waterfowl population
        - Salmon in Porcupine River
        - Caribou birth rate and population
        - Temperature data
    - Web site is good forum for advocating important indicators, even if now there are poor data for them
- Personal factors, such as EMAN-N coordinator's (Joan Eamer) dedication

Weaknesses:
- Structural: Too big and widespread Board, difficult to work with
- Lack of aggregation: Shopping list type of variables
- Some data sets hang out in isolation
    - No reason to abandon monitoring, even if present data are scarce, such as polar bear abundance

Potential for aggregation:
Index construction is possible on the basis of existing indicators.
- Index of snow condition, based on the influence of temperature-precipitation-climate variables
- Index of river ice condition (based on climate change, effect on river conditions such as overflow)
- How physical variables influence biological variables
    - E.g. snow levels effect on caribou movement
    - How these impact humans, e.g. travel across land

Integration:
This is the ultimate goal; this would help get real understanding of information. Small steps: How indicators are related to and complement other community monitoring information.
- Integration happens frequently at community meetings and discussions
    - E.g. monitoring shows low salmon population, but community's supply was adequate due to salmons closeness to shore
- Overall synthesis is too complex and nobody can do it yet
    - Instead: Pointed questions, such as: How caribou monitoring data relate to community observations (is it possible to get enough caribou meat?)
- There are different ways of collecting and interpreting data
- Needs to flash out information to better understand consequences on wildlife and humans

KING, LESLIE (ArcticNet; U of Manitoba)

Role in ArcticNet: Theme 4.7 (Science and human development)

- The importance of the human dimension in the ecosystem:
  - Human, biotic and abiotic dimensions are more tightly coupled in the North than anywhere else
  - Life directly depends on other dimensions
- Health of Northern and Arctic communities is the best indicator of ecosystem health
  - E.g. sea ice conditions have impacts on people's food, travel, entire livelihood → if these conditions deteriorate, the health of the population also deteriorates
  - Sustainable healthy communities project: Minor project, but proves that people identify healthy community with healthy ecosystem

Contact: *Tim Papakyriakou (U of M)*
Jill Oakes (U of M)
Rick Riewe (U of M)

MCBEAN, GORDON (U of Waterloo, ArcticNet)

Nature of work: He is the lead of Theme 4 (Integration), the team's immediate task is to mediate science to policy makers. They are at the beginning of their work that will be based on the findings of the scientific theme teams. They have to clarify what policy makers want, what is important for them. This clarification is important also for the NEI indicator inventory: What is the purpose of making the inventory from a non-scientific, policy making perspective?

He advised to consider the Canadian Institute for Advanced Research's work on ecosystem management research.

Interpretation of ecosystem:
He emphasized the importance of considering the interpretation of ecosystem beyond its narrow, internal (nature-focused) definition and follow a broader, more holistic approach (that better relates to sustainable development) to include external stressors as well.

Such externally imposed stressors are, among others:

- Climate change indicators
- Toxic pollutant indicators
- Economic stressors
- Social stressors

Systemic thinking requires that people should be viewed as part of the ecosystem.

Expectation for present inventory:
From decision making perspective, ecosystem indicators have several important functions, e.g.:

- Advise Northern communities for best adaptation strategies
- Decide whether acting is needed locally, regionally or globally
- Help rightly dispose energy of actors: How to compare the benefit of actions

Indicators can help decide how investments to achieve change should be made with better payoff.

Research projects and facilitation are aimed at coming up with integrated regional studies.

Integration:
Spatially varying pieces of information based on most diverse data means that integration of information is most difficult. Even in a relatively simple case like for temperature data it is not trivial; for the ecosystem as a whole it is even more complex.

Ways to integrate: Depend on economic and social questions that we try to manage; subjective weighting by issues is unavoidable. We need standardization and to make the results compatible with international findings.

PAPAKYRIAKOU, TIM (U of Manitoba)

Nature of work: Looking at micro-climate in different circumstances to better understand impact of atmosphere and climate on surface and sub-surface; to better understand flows that link elements of biosphere (such as coastal environment) to atmosphere.

- Hudson Bay area: Collecting variables and having good time series to look at variations on different scales (records of transitions) to understand process
    - Soil moisture and temperature; air temperature
    - Data for the past 35 years
- High Arctic archipelago: Surface experiments since early 1990s. Sensitive area to change: interesting interface zone to look for change and understand process (started in 1990 at U of Waterloo)
    - ArcticNet: reconstruct regional coverage to understand system from oceanographic perspective
    - Dedicated stations to develop very detailed understanding locally, but mostly regional research, with very few samples from different locations
- Investigating climate influence on plant physiology
    - Vaporization pattern by measuring moisture availability to plants

Data processing/aggregation:

- No experience in transforming data into aggregates
- Reason to transform data: Inform an audience on the rate and kind of surface change
- Need for politically and/or culturally sensitive and neutral monitoring

Challenge to ArcticNet:

Broadening focus (for Theme 4!): Channeling info to general audience

- Theme groups communicate requirements and exercise quality control
- Role of Network: communication, informing participants
- Develop a tool to map out sensitivity of the system
    - *Integrate* hydrology and study of biological system in Sub-Arctic watersheds → project impact of climate change on vegetation dynamics
    - Deliverable and robust tool, using Theme 4 to link findings to other parts of the system

Variables that could help define ecosystem indicators:

- Records of transition in soil moisture and temperatures and air temperature can be used as an index of seasonal change
- Data on moisture availability to plants can be used to create a dryness index

RAUTIO, MILLA (ArcticNet; Laval University)

Theme 2/Northern Regional impacts and Sensitivity to Climate Change of ArcticNet focuses on the terrestrial and freshwater environments of the coastal Arctic, with research activities in eastern Canada from Hudson Bay to the northern limit of Nunavut. They are following a diverse set of indicators in six project sub-themes (wildlife, freshwater, human health, permafrost, culture and tundra) in the context of climate change.
Science coordinator for this Theme: Dr. Milla Rautio.

Work is under way for less than a year, with a huge team working together since April 2004.

Integration:
Integration is difficult because of the many disciplines and communities involved. Wide geographic coverage, but sites are visited only infrequently.
Integration was a consideration from the beginning of project design in site selection

- people are still individual researchers interested in their own studies
- out of the six projects one (Water) is in big part based on communicating with communities (drinking water quality)
- permafrost scientists also work around communities (house construction, road building)

Distinction between indicators and variables:

- Sometimes misleading because of overlaps; e.g. temperature variables are climate change indicators
- Small lakes response to climate change: measured by temperature increase, UV radiation
- Just started to collect variables to feed into Theme 4 → indicator compilation

Lessons (to be) learned:
Keep and provide information to all network investigators

- Lack of sufficient communication and cooperation among investigators → demand, but no supply
- Need to provide info to the public, not just pursue individual research (200 members per themes!)
- Data-sharing and networking is the challenge
    - Limitations of info networks, bureaucratic hurdles, overwhelmed by info requests and not able to network
- Info to communities should be one of the products

Scientifically very high quality of research

- Individual researchers' databases need integration and easier accessibility
- Harmonization has limited possibilities
- Part of the research programs are publicly searchable

Positive overlaps with others working on the North

- Arctic research is too rare: every supporting info is welcome
- ArcticNet brings many scientists together to work on the North

SHIRLEY, JAMAL (Nunavut Research Institute)

Institute's programs are presented more broadly than indicator programs, though they include true indicators:

- Bird population parameters of species of interest
- Status and trend of selected marine and terrestrial birds (CWS): ecosystem changes
- Status and trends of polar bear population: ecosystem changes
- Sea ice changes (CIS): climate change
- Plant phenology (Arctic plant development control monitoring), on altered plots: climate change *Additional contact: Greg Henry, UBC*

Aggregation: No, though needed for comprehensive SOE report for Nunavut. No mechanism to integrate disparate data that would be useful for policy makers
Data for management purposes: baseline monitoring data for impact assessment; data are contained in specific departments, not integrated, though data sharing is important
Land claims and entitlements for info on environmental and socio-economic conditions → needs integration into the Nunavut General Monitoring Program

NRI activities: In the process of developing capacity to design monitoring program and assessment methodology (based on a northern application of the rapid bio-assessment approach) for the community structure of invertebrates to assess the environmental integrity (water quality and stressors) of streams, by comparing different sites.
The Institute is involved in the CCAN; it is the Nunavut center facilitating research logistics, and in EMAN-North
Institutional contacts: Churchill Northern Studies Centre; no project specific cooperation

International commitments: Participation in NCP: scientific justification for the Stockholm Treaty (indicators are tremendously important; see Hg and POP); similarly contribution to the Climate Change Protocol through participating in the Arctic Council's work, supporting long term policy components

Lessons learned: (based on 5 years of involvement)

- Most often the links to decision-making is not factored in the design methodology of monitoring and indicator work
- Struggling for buy-in from potential supporting and advocacy organization to convince them that there are good data they need
- Need for applied monitoring; most monitoring are designed for scientific goals – these need to be complemented by management and decision-making related objectives. E.g. monitoring wildlife for management programs (population and harvest rates are observed for key species for harvest management)
- Community involvement and outreach is crucial: design of monitoring must ensure meaningful local participation, must understand limits of participations and needs benchmarks and identification of critical thresholds (compensation, time allocation, paid vs. voluntary participation)
- Tensions between scientists and locals may falter programs

- Positive outcomes, local employment and training opportunities are important conditions of success (criteria for funding wildlife monitoring programs)

Expectations from inventory project:

- See a final list of indicators and how they are used in different jurisdictions for assessment and management
- Fill a critical gap of knowing who's doing what and where
- Data sharing

WAKELYN, LESLIE (EMAN-N)

Was interviewed with Eamer, Joan. Please refer to that interview.

Appendix 3: Complete List of Indicators Reviewed

Is available in a separate electronic file.