SAON II: Report from the Breakout Group on Terrestrial Observation Networks

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1. Introduction

a. Challenge and Opportunity

The Arctic is undergoing rapid change and experiencing growing pressure from a variety of sources such as climate change, resource development and contaminants. Meanwhile established research and observing networks remain largely uncoordinated, limiting their ability to effectively monitor, understand and respond to changes occurring at a variety of temporal and spatial scales. The maintenance of healthy Arctic ecosystems is a global imperative as the Arctic plays a critical role in the Earth's physical, chemical and biological balance. The challenge and opportunity before us is to develop a comprehensive, integrated and sustained pan-Arctic observing network to facilitate more rapid detection of current trends, forecast future trends, understand the underlying causes driving trends and effectively deliver this information to public and policy arenas. This integrated network would utilize both scientific and community-based monitoring approaches, be linked to global and extra-Arctic initiatives and would provide accessible, current, and accurate information on Arctic change.

b. Terrestrial Observation Network Breakout Process

The SAON II Terrestrial Observation Network breakout session built upon the results of two previous Terrestrial and Freshwater Ecosystems SAON breakout sessions. These previous breakout sessions, within the context of Arctic Terrestrial Ecosystems, had addressed the following questions:

- What Arctic observing sites, systems and networks currently exist?
- What spatial, temporal and disciplinary gaps exist?
- How will gaps be filled and the entire effort sustained?

The Terrestrial Observation Network breakout session at SAON II included consideration of not only terrestrial networks, but also freshwater observing networks to ensure consistency with the previous sessions. This breakout session placed a particular emphasis on the requirements of operational agencies (national agencies responsible for national monitoring and observing), their mandates, and their potential to support sustainable Arctic observing networks. The overall goal of this session was to identify user needs from both the operational and research community perspective and develop a set of recommendations for national governments and the Arctic Council for improving integration and sustaining Arctic terrestrial and freshwater observing networks.

The following questions focused the breakout group discussion:

- What is the intersection between operational activities and research?
- How are international and national networks organized?
- Opportunities for integration across networks?
- How can data management and data infrastructure be strengthened?
- How can infrastructure and equipment needs be met?
- How do we sustain our observing networks?

Four existing terrestrial/freshwater observing networks were highlighted to provide insight into current approaches for integrating Arctic observing and to serve as examples of the diversity of existing networks that an integrated, pan-Arctic approach can build upon. The highlighted networks were:

- *International Network of Permafrost Observatories (Presenter: Dr. Jerry Brown),*
- *Arctic Wildlife Observatories Linking Vulnerable Ecosystems (Arctic WOLVES) (Presenter: Dr. Gilles Gauthier),*
- *Circum-Arctic Network of Terrestrial Field Bases (SCANNET) (Presenter: Margareta Johansson),* and,
- *Circum-Arctic Environmental Observatories Network (CEON) (Presenter: Dr. Craig Tweedie).*

These highlighted examples provided the break-out group with some context to which we could answer the above questions and develop a concept and recommendations for integrating and sustaining Arctic terrestrial and freshwater observing networks.

c. User Groups Represented

The user groups represented at the breakout session included international research committees, academic institutions, and government agencies (particularly Canadian government agencies with some operational agencies represented). This included representatives from not only terrestrial observing networks, but also freshwater observing networks. The group lacked representation from Arctic communities, Aboriginal organizations, industry and regulatory agencies.

2. What is the intersection between operational activities and research?

There already exists a close connection between operational activities and research highlighting the symbiotic relationship between such networks. Operational networks identify change while research networks can identify the causes of change. These insights can be used to develop models for predicting future change. Operational networks also generate long-term data sets that populates predictive models allowing for model testing and refinement, thereby, improving our ability to predict change. Operational networks also benefit from research activities as ongoing monitoring evolves and improves as research provides insight into ecological relationships and develops more effective methods of observation.

More specifically, research networks inherently depend upon operational networks for a variety of environmental data including climate, hydrology and population survey data both derived from ground stations and satellite imagery. For instance, the International Network of Permafrost Observatories directly relies upon data derived from operational meteorological stations. This network does not have the capacity to collect ground and soil temperature records across the Arctic and therefore, is dependent upon existing government-run extensive networks of meteorological stations for this data.

Beyond this, operational networks and flagship observatories (intensive research and monitoring sites) typically collect and maintain long-term datasets focused on core elements (species, processes, etc.) of the ecosystem whereas research networks and programs are often focused on short-term experimental manipulations to explore hypotheses. Further integration of the two is needed and there are good examples of such integration. Many flagship observatories combine the two, with long-term, sustained monitoring of core ecosystem elements augmented with specific research activities to advance our understanding of ecological relationships and processes. These observatories are typically flexible in nature allowing them to adapt their monitoring with advances in knowledge of ecosystem processes and relationships and address emerging issues.

3. How are International, National and Regional Networks Organized?

A variety of terrestrial and freshwater observing networks are currently active across the Arctic operating at a variety of scales. These networks represent a diversity of disciplines and themes and, as a result, represent a variety of approaches and utilize and require different types of infrastructure. These networks can be classified into two broad categories:

- Site-based Networks (research stations)
- Theme-based Networks (organized by: disciplines, species, geographic regions)

Site-based networks typically represent a multi-disciplinary approach, undertaking a wide range of inter-related research and monitoring activities replicated across a series of research stations or sites. Theme-based networks are either organized around a particular discipline (e.g. permafrost monitoring), species (e.g. Barren-ground Caribou), guild (e.g. Seabirds) or defined geographic region (e.g. Bering Sea Sub-network). These networks may, or may not, utilize research stations and sites, in some cases involving extensive monitoring across a broadly defined geographic area (e.g. Caribou herd monitoring). Some networks utilize only traditional scientific approaches while others also utilize community-based monitoring approaches making use of the capacity and knowledge offered by local citizens in the Arctic. The challenge is to develop an inclusive overall vision and approach that allows integration of these diverse observing networks and utilizes both community-based and more traditional scientific monitoring approaches.

4. Opportunities for Integration Across Networks

Acknowledging limited resources, the recommended approach is to focus efforts on developing and formalizing a network of networks based first on observing networks in existence. Significant investments in infrastructure and observing have been made by a number of networks across the Arctic and any integrated, pan-Arctic network must build on this investment. As new resources become available, gradual development of new networks and sites could be made to strategically fill critical gaps in bio-geo-climatic (environmental envelopes – see Callaghan diagram in SAON I report) or thematic coverage. This network of networks would be comprised of both intensive (flagship observatories) and extensive monitoring networks (less intensive monitoring sites and networks) and would include site-based research station networks, theme-based networks and remote sensing networks. An example of this concept can be found in Figure 7.1 of the Overview of the Second International Conference on Arctic Research Planning. Integration across biomes and systems (e.g. marine-terrestrial-atmosphere) would be an intrinsic feature of such a network of networks. The development of a comprehensive, integrated network of networks would be guided by integrated research and monitoring plans (top down integration) that closely reflect existing national and international research (e.g. ICARP II) and reporting mandates and build upon the existing observing networks. Developing a coordinated and integrated network of networks would provide much added value to our existing observing efforts. A network of complimentary intensive and extensive observing incorporating both scientific and community-based monitoring approaches would provide a much more complete understanding of change. Coordination of monitoring at the circumpolar scale would improve our ability to quickly detect and attribute important environmental trends.

A number of efforts are currently underway to improve the coordination and integration of existing terrestrial and freshwater networks. One example is the ongoing expansion of SCANNET with North American observatories (research stations) now joining the network. Another example is the Circumpolar Biodiversity Monitoring Program's development of five Expert Monitoring Groups (Marine, Coastal, Freshwater, Terrestrial Vegetation and Terrestrial Fauna). These Expert Monitoring Groups will be developing integrated, long-term biodiversity monitoring plans to facilitate integration and standardization of biodiversity monitoring across the Arctic. These plans include the identification and implementation of optimal, pan-Arctic sampling schemes and standardized parameters and protocols.

The establishment of a network of networks requires a coordinating entity and tools that promote and facilitate integration. We recommend the following activities:

- Establish a Secretariat for developing and coordinating a network of networks that integrates existing site-based and theme-based networks and identifies gaps in the network that could be filled with additional funding. This Secretariat would likely be best situated within the auspices of the Arctic Council. The World Meteorological Organization and the Circumpolar Biodiversity Monitoring Program provide possible models for such an approach.

- Develop a core set of 'best monitoring' protocols. These protocols would facilitate a common, standardized and integrated pan-Arctic monitoring approach. This core set of standardized protocols should focus on simple, repeatable and inexpensive measures that can be implemented on a circumpolar basis. This project would include the development of an inventory of existing parameters and protocols in use.

Such an effort would have to develop a vision and approach that allows for coordination between networks that are organized very differently. Intensive networks, by their nature, have seen some level of integration and standardization between sites, whereas observing networks that are widespread and less intensive have less often had this level of integration. Extensive networks are organized differently from intensive networks as research networks are organized differently from operational networks. A key challenge would be to provide a mechanism for the integration of these diverse networks.

5. How can data & metadata management and data infrastructure be strengthened?

Data management should be designed upfront to serve desired reporting outputs (information management) and user needs in general, thereby ensuring data accessibility and effective products for decision makers and the public. Data management design should also go beyond passive data collection and management to also include interpretation functions. There are a number of programs that serve as good data management examples in this regard including many national fire management programs, the World Meteorological Organization and the Zackenberg research station.

Existing and new cyber-infrastructure technologies should be employed to streamline data archiving, data formatting, and data access. The biological sciences, in particular, would benefit from data archiving, formatting and access technologies as biological data comes in a variety of forms and media. Streamlining would include developing distributed, interoperable single-entry data portals that allow simple and efficient discovery and access to current metadata and data. These portals should be compatible with existing and planned global data portals and should include a searchable meta-database of existing Arctic monitoring networks, monitoring protocols in use and existing data. The development of this meta-database would be directly supported by an inventory of current monitoring programs, protocols and data (see Section 4). While existing and new CI technologies offer significant opportunities for improved data management and accessibility, care must be taken to ensure strong connections between the data available and the original data collectors to reduce the risk of misinterpretation.

Data infrastructure needs include improved and expanded archiving capacity for specimens, tissues and other samples. Expertise for archiving these samples typically is found within academic institutions and museums. Linkages with and support to these institutions is required to ensure sustained maintenance of these samples. New techniques and technologies offer more efficient sample storage with increasingly smaller samples needed to perform complex analyses.

Funding processes need to support these activities by demanding upfront data management, formatting, access and archiving.

6. **How can infrastructure and equipment needs be met?**

Operational costs, particularly transport costs, are comparatively high in the Arctic. With limited resources currently available and the need to maintain our current, and often long-term, investment in Arctic observing, it is recommended that infrastructure and equipment needs of existing sites and networks first be met before providing new resources for additional sites and networks.

In many instances, transport costs are the greatest cost for Arctic observing networks working in remote areas of the Arctic. Strategic transport support, adoption of new technologies and the use of local people or researcher multi-tasking is needed to sustain or increase observations in remote Arctic regions. The establishment of a central coordinating entity for managing pan-Arctic logistics and cost sharing on existing transport platforms (e.g. Coast Guard, Military, Industry, Research transport and vessels) would likely realize cost savings far beyond the annual cost of operating the central coordinating body. Existing data management software technologies could be employed to streamline the identification and management of transport sharing opportunities. Also, simple and repeatable measures that can be conducted by others (community people, other researchers) could also realize significant cost-savings and therefore, increase sampling opportunities. In some cases, new technology such as Un-manned Rovers could provide some opportunities for reduced sampling costs or, at least, lesser operational risk. We recommend that the InfraPolar paper be consulted for information on streamlining logistics costs.

7. **How do we sustain our integrated network of networks?**

At present, most observing networks are operating on limited and unstable funding. Many of these networks maintain highly valuable long-term data sets and maintain significant investments in infrastructure and equipment. It is imperative that initial efforts for sustaining Arctic observing focus on securing our current investment. As new resources become available, strategic investments in new observing networks and sites could be made to fill key gaps in bio-geo-climatic and thematic coverage.

Arctic Council and national governments can play a key role in sustaining an integrated network of Arctic observing networks. This could be furthered through an Arctic Council commitment to establish a coordinating body for such a network of networks. National governments could enshrine the mandate and support for long-term, integrated monitoring programs through legislation. Funding agencies could be re-tooled to provide multi-year funding and support beyond just monitoring to also include data management and reporting.

Existing observing networks also have a key role in improving the sustainability of their programs. It is recommended that networks develop shared communications and outreach capacity that regularly translates scientific products and publications into products that directly target the Arctic Council, politicians and the public with clear and simple results. These products should go beyond reporting what has changed to also include predictions and cost-benefit analyses concerning particular policy options. Couching current monitoring as risk management (reducing risk in decision making) would likely increase funding opportunities. Products derived from monitoring must also target reporting processes, user needs, and regulatory requirements (e.g. monitoring the results of mitigation or adaptation actions) – particularly at the regional and local level where most decisions are made. As noted earlier, observing programs should be designed with product and reporting needs in mind and should be clearly aligned with international science planning and national research priorities.

The use of examples can also be a powerful tool for increasing support for monitoring. Many examples of where decisions were improved because of the presence of long-term data or conversely, where poor decisions were made due to lack of long-term data can be illustrated.

Finally, existing observing networks can improve funding opportunities through their own efforts to integrate with other networks. This includes actively involving local community members in research and monitoring activities. This is critical in order to maintain local support for observing activities – a key requirement for many funding sources.