Assessing the Effects of Climate Change on Lakes of Ontario's Boreal Shield

Proceedings of the Sudbury Climate Change Workshop

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Summary

- The Boreal Shield Ecozone contains most of Ontario's lakes. Aquatic ecosystems on the Boreal Shield are expected to be very sensitive to climate change and climate variability.

- The effects of changing climate are not independent of the effects of other important environmental stressors, and need to be assessed in the context of multiple, interacting stressors.

- There is an important need to develop our understanding of the current and expected impacts of climate change, and of the interactions of climate change with other stressors, to permit the development of appropriate adaptive strategies for waters on the Boreal Shield.

- A number of world-class research and monitoring sites exist in Ontario that have been conducting aquatic studies for several decades. Linking these federally and provincially operated sites into a network provides the most effective framework for implementing an aquatic assessment program on the Boreal Shield.

- Substantial progress on the establishment of an Ontario Network has been made. The Cooperative Freshwater Ecology Unit at Laurentian University is coordinating Network development, the agencies involved in operating the individual sites have formally agreed to collaborate, and a number of cooperative projects between Network sites have been initiated.

- The long-term success of the Ontario Boreal Shield Network will depend on securing the resources necessary for ongoing coordination, and will require continuing support from the various agencies involved, to maintain the existing research and monitoring sites in Ontario.

Introduction

The Boreal Shield Ecozone is a particularly important and sensitive region of Ontario, which contains most of Ontario's lakes. Aquatic ecosystems on the Boreal Shield are expected to respond strongly to climate change and climate variability, but with significant differences across the ecozone and among adjacent systems. Climate models predict that the various regions of the Boreal Shield ecozone will vary greatly in the magnitude of expected changes in temperature and precipitation. These differences in climate changes across the ecozone are overlaid on chemical and physical characteristics of individual waters that will affect how they respond to climate change. There is an important need to better understand the impacts of climate change on the water resources of the Boreal Shield. A great opportunity to exists to capitalize on the fact that a number of world-class aquatic research and monitoring sites already exist in Ontario. Sites conducting long-term aquatic studies include, from west to east:

- Experimental Lakes Area (ELA); in northwestern Ontario,
- Turkey Lakes Watershed/Algoma lakes; in the Algoma Region of Ontario,
- Killarney Park/Sudbury lakes; in northeastern Ontario.
- Dorset/Algonquin Park lakes; in central Ontario,

All of these areas (Figure 1) have research and monitoring programs that have been active for at least several decades. Great potential exists to combine these sites into an effective provincial network. Specific objectives addressed by the Sudbury Climate Change Workshop, Feb. 23, 2001 included:

- Developing a framework for coordinating studies of the effects of climate change on Boreal Shield waters at existing long-term research and monitoring sites.
- Establishing strong linkages and developing collaborative research projects between internationally recognized aquatic research and monitoring sites in Ontario that are operated by the federal and provincial governments and universities.

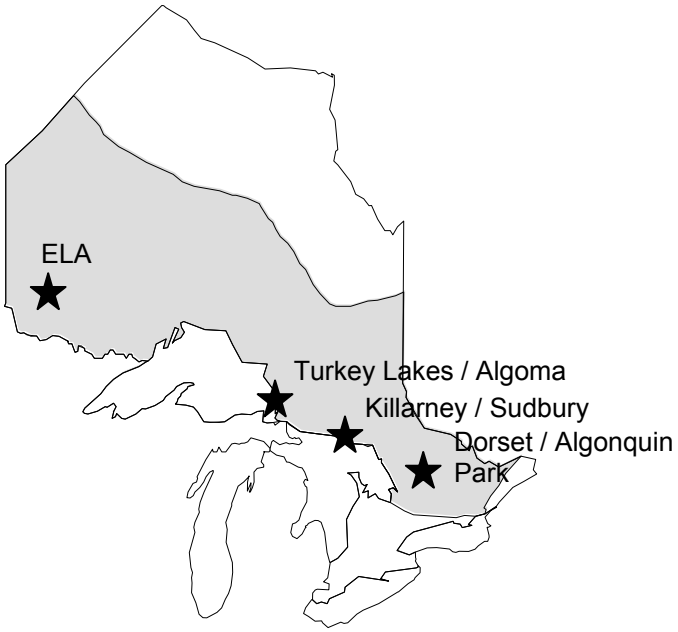

Figure 1. Locations of existing long-term aquatic research and monitoring sites on the Boreal Shield in Ontario.

Climate Change and the Lakes of the Boreal Shield

Many aspects of climate change have important implications for aquatic ecosystems. Temperature, in particular, is known to have major effects on nutrient dynamics and on many other physical and chemical characteristics of lakes. Temperature regimes affect the distributions, growth and survival of fish and many other aquatic organisms. Variations in precipitation can cause substantial physical and chemical changes in lakes and streams, with large consequences for aquatic biota. Droughts, for example, can greatly affect lake transparency and thermal structure, alter chemical cycling, affect streamflows and water residence time in lakes, and induce contaminant mobilization. Such effects on aquatic ecosystems may not, however, be simple and direct. The effects of climate change are known to interact with the effects of many other stressors, including for example the effects of large scale stressors like acidification and UV-B irradiance, and the invasion of warm-water exotic species.

While the magnitudes of the expected impacts are uncertain, there is agreement within the scientific community that a changing climate will result in significant impacts to our aquatic resources. We need to better understand the impacts, if we are to manage our aquatic resources to be sustainable in a changing climate. To understand impacts, we require accurate information on the current rates and patterns of change and we need to be in a position to reliably predict future changes. Effective assessment and prediction of climate change effects must be conducted in the context of the multiple stresses affecting the Ontario environment. Long-term data collected on many individual sites subjected to varying degrees of other

stressors are necessary to assess the impacts of climate change on aquatic ecosystems and make accurate predictions of future change.

The Network Approach to Assessing the Effects of Climate Change

The February 23, 2001 Sudbury Climate Change Workshop, was attended by representatives from the various sites with potential for inclusion in an Ontario Boreal Shield Lakes Climate Change Network (participants list attached). The agencies and organizations represented included Ontario Ministry of the Environment, Ontario Ministry of Natural Resources, Environment Canada, York University, Laurentian University, Trent University, and the University of Toronto. There was agreement that the existing long-term research and monitoring sites in Ontario can be linked into an effective provincial network. Representatives from the sites have since formally agreed, through a memorandum of understanding (attached), to cooperate in making this network a reality.

Current Status:

The existing study sites do not necessarily include a statistically representative sample of waters in the province; however, they do broadly represent freshwater ecosystems across the Boreal Shield. The sites vary in forest type and current climatic conditions. They also vary in the extent to which they are expected to be affected by climate change, and span a range in the degree to which they are affected by other large-scale stressors such as acid deposition, exotic species and shoreline development. Such variations must be included in a provincial assessment network if we are to understand the implications of climate change amid a background of multiple stresses. An effective monitoring network for detecting climate change effects must be able to isolate climate-induced impacts from impacts caused by other stressors, and determine interactions between stressors.

These sites were established to monitor changes in aquatic systems for various reasons, often for the study of acidification. While there is much similarity in the assessment approaches taken at different sites, there are also differences that will need to be considered as the Network develops. As well, the demands of dealing with a new issue, Climate Change, will require a review of the approaches taken at all sites and may lead to changes or additions to our assessment strategies. Additional or alternate assessment techniques will likely need to be developed and monitoring programs may need to be implemented on additional waters to strengthen the Network.

Progress on Integration Into a Network:

Coordination

The Cooperative Freshwater Ecology Unit (Co-op Unit) at Laurentian University, has been selected as the centre of coordination for the Network. Dr. Shelley Arnott, Laurentian University, is currently providing the scientific coordination for the Network. The Co-op Unit has been in operation since 1989, and has played a similar role in other multi-agency and multidisciplinary projects. The Co-op Unit is expanding and refocusing its activities within the context of climate change and multiple, interacting environmental stresses, and is well positioned to serve as an effective centre for coordination.

A key requirement for an effective network is the establishment of efficient information sharing mechanisms between sites. As an initial step toward this goal, the Co-op Unit will compile a data catalogue summarizing the specific data that are available from each of the sites in the Network. The data catalogue will allow researchers at different sites to identify opportunities for direct collaboration with other sites, and will allow an overall assessment of any gaps and weaknesses that may exist in the Network, which will need to be addressed. Once the nature of the collective databases available within the network is clearly known, plans to further expedite data sharing abilities will be developed. In an important step to strengthen data management capabilities, Martyn Futter, Ministry of the Environment, has been reassigned to the Co-op Unit.

Effective collaboration between sites will also require regular meetings for information exchange and planning purposes. The Co-op Unit will host the next major Network meeting on Climate Change and Multiple Environmental Stresses, during February 20-22, 2002, in Sudbury. In order to maximize information gain, participants in the Network feel that it is important that formal collaboration be initiated with international scientists and agencies that are also dealing with the same issues - management of waters on the Boreal Shield under changing climatic conditions against a background of multiple additional stressors. International contacts (Norway, Wisconsin, New York) have already been established through the Co-op Unit. The Norwegian Research Council has requested that the Co-op Unit referee some of the proposals that they receive for climate change research in Norway. The next meeting in Sudbury in 2002 will include representatives from Shield ecosystems throughout the world.

Some of the sites in the Network (Experimental Lakes Area, Killarney Park, Turkey Lakes, Dorset) have already been included in the national Environmental Monitoring and Assessment Network (EMAN). This relationship with EMAN needs to be continued and expanded to further assist in the enhancement of communication and collaboration between research and monitoring sites across Canada. A presentation on the Ontario Network was given at the May 2001 EMAN meeting in Calgary. It is planned that a representative from the Ontario Network will attend all future EMAN annual meetings.

Collaboration

Discussions at the Sudbury Climate Change Workshop identified a number of areas in which collaborative research is needed to address important climate-related questions, and can best be conducted through a network approach. Specific collaborative research projects are being developed to address the above research areas. These include:

- Paleolimnological Studies - Long term Trends

The great potential of incorporating paleolimnological studies of lake sediments within the network approach was clearly recognized. Paleolimnology provides the opportunity to infer the effects of climate change and other stressors from patterns of change over centuries, not just decades as in most monitoring programs. By examining long-term changes in climate-related variables in lakes, across the gradient of the other stresses inherent in the Network, there is an opportunity to determine the relative roles of individual stressors. Climate-related paleolimnological studies have recently been initiated at the Killarney/Sudbury Site. Paleolimnological data do exist from some other sites in the Network, but the assessment being conducted through the data catalogue is needed to identify what data are currently available for analysis from which sites, and what data gaps will need to be filled to examine patterns across the Network.

- Effects of Climate on the Storage and Mobilization of Sulphur

Drought results in the oxidation of reduced sulphur stored in watersheds and lake sediments from decades of elevated atmospheric deposition. Wetlands are a key site of sulphur storage. Remobilization of this stored acidity under wet conditions can result in re-acidification or delayed recovery of lakes and streams, and many other related changes including mobilization of metals and base cations. The size and availability of the stored sulphur pool, how long such effects may continue, or whether such effects will increase with a changing climate are not known. This issue can be addressed by combining laboratory and field experiments on the nature and availability of the sulphur pool with analyses of patterns in lake and stream chemistry and hydrology as they relate to patterns in climate. By utilizing the network approach, sites can be compared that have had very different sulphur deposition histories, offering the opportunity to isolate climate effects.

- Effects of Climate Change on Nearshore Biota

One area where the climate signal is expected to be particularly strong is in the coupling of changes in air temperature with changes in the temperature of near-surface waters. These areas of lakes, particularly the littoral zone, are typically species rich and are very important in terms of energy flow. A project is underway to examine littoral microcrustacean communities across a gradient of lakes within the Network. A follow up project examining littoral macroinvertebrate communities through rapid bioassessment techniques is being planned.

- Effects of Climate Change on Zooplankton

Analyses of long-term seasonal data sets can be used to determine the directions and duration of the general responses by pelagic zooplankton communities, to the direct or indirect effects of climate. Changes in the timing of ice-out and thermal stratification may have important influences on aquatic communities because conditions early in the season, immediately after ice-out, may set the stage for many of the biological interactions that determine the annual community composition. Interannual variation in plankton community structure will be examined in relation to the timing of ice-out and the development of thermal stratification. In addition to analyses of existing data series, a project is needed to examine the short-term aspects of community development (immediately after ice-out) and how this is influenced by factors such as warming rate, timing of ice-out, etc. To augment information in the long-term databases, temporally intensive zooplankton sampling will be initiated at a few lakes at each of several network sites for 3 years.

- Interactions with Fish Communities

Fish communities respond to climate changes (e.g. northern movement of warm-water species such as bass) and modeling projects are underway to assess the potential impacts of climate change on the expected yield of various sportfish species. However, fish also have significant modifying effects on other biotic communities, effects that may be altered by climate change. Up to date information is needed on the status of fish communities in the study lakes in the Network. Discussions are underway to attempt to provide standard assessment information on fish communities.

Future Needs:

Effective coordination of the Network in the long-term will require an investment of resources. A Scientific Coordinator is needed to help initiate and conduct collaborative research projects between sites in the Network. He/she will provide the ongoing liaison between sites and facilitate the further development of the Network and the integration of scientific results from the Network. The ongoing part time services of a Data Manager will be required to maintain and update the Network data catalogue and provide assistance with data exchanges within the Network and with other collaborators.

To encourage inter-site collaboration on research projects, a fund needs to be established to assist students with travel/accommodation costs if they are conducting projects that include work at two or more Network sites. The Coordination Centre also requires a pool of funds that can be directed to address specific needs that are identified as priorities within the Network. This fund will provide support and seed money to initiate research projects or to fill gaps that are identified in the monitoring programs. Ongoing support will be required for general operating expenses and hosting the annual Network meeting.

In addition to coordination resources, the agencies involved will need to provide the resources necessary to maintain and enhance where required the research and monitoring programs at the sites in the Network, since these are the basis for the network approach to assessing the current and expected impacts of Climate Change and related environmental stressors on the waters of the Boreal Shield.

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Memorandum of Understanding
for the
Development of a Network for Assessing the Effects of Climate Change
on the
Waters of the Boreal Shield in Ontario

Rationale:

Recent evidence from modeling and monitoring studies suggests that climate change will have severe effects on lakes and streams in the Boreal Shield landscape. The Boreal Shield is the largest ecozone in Canada and contains most of our freshwater resources. Although vast in number, the aquatic ecosystems of the Boreal Shield are relatively unproductive and are often highly sensitive to human disturbances such as exploitation, acidification and contaminant deposition.

In Ontario, we are fortunate to have a number of well established monitoring sites on the Shield that have been in operation for many years and are now useful for tracking the effects of climate change. These are a mixture of provincial and federal sites, some with strong university involvement. Several of the sites are already part of the Canadian EMAN (Ecological Monitoring and Assessment Network) Network. The sites were established to monitor changes in shield lakes for a variety of reasons, with acidification monitoring being one of the most common objectives. Existing monitoring sites do not necessarily include a statistically representative sample of the various sizes and types of lakes on the shield, but they do represent a broad range of freshwater ecosystems from the ecozone. Existing sites also span a wide range in the degree to which they are affected by other large-scale stressors such as acid deposition, exotic species and shoreline development. Assessment of the effects of climate change on Boreal Shield waters will need to be conducted against this background of multiple environmental stresses and potential confounding factors.

There is a strong need for an integrated monitoring program to provide resource managers with the understanding of current impacts and potential future impacts of climate change and the interactions of climate change with other stressors. An excellent opportunity exists to build on the current monitoring studies in Ontario to develop an integrated Climate Change Monitoring Network for waters on the Boreal Shield. Close cooperation among sites is necessary to develop and maintain such a network.

Principles for Cooperation:

Sites in the Shield Network:

The study sites that need to be linked in an Ontario Network to monitor the effects of climate change on aquatic ecosystems on the Boreal Shield are:

- Experimental lakes Area (ELA); in northwestern Ontario
- Turkey Lakes Watershed in the Algoma Region of Ontario
- Killarney Park/Sudbury lakes; in northeastern Ontario
- Dorset lakes; in central Ontario
- Algonquin Park lakes; in central Ontario

Many of these sites support several complementary scientific activities by different agencies.

Activities of the Shield Network:

The main elements of the cooperation needed to develop an integrated Boreal Shield Network include:

- Developing routine and effective data sharing and communication procedures between sites in the Network
- Striving for standardization of variables measured, and measurement techniques
- Developing collaborative research projects between sites to address specific issues
- Holding annual meetings with principals from the different sites to review progress, develop collaborative research plans and ensure effective information exchange

Cooperation in a Boreal Shield Waters Network will lead to:

- Advancement in the understanding of the current effects and potential effects of climate change on Boreal Shield waters, and their interactions with other environmental stressors
- Identification of gaps or inadequacies in current programs that need to be addressed through changes/additions to programs
- Economic efficiency of research and monitoring efforts through collaboration

By this Memorandum of Understanding the agencies conducting scientific activities at these sites agree to formalize cooperation in their research and monitoring activities, following the above principles, to lead to an integrated assessment program of the effects of climate change on Boreal Shield waters. For the period 2001-2006, staff of the Cooperative Freshwater Ecology Unit at Lautentian University in Sudbury agree to provide the coordination role for the Network.

(Signature)	(Date)	
	11 May 2001	Experimental Lakes Area
	March 19/01	Dorset Environmental Science Centre
	28/3/01	Turkey Lakes Watershed
	April 20/01	Harkness Fisheries Laboratory
	March 2/2001	Cooperative Freshwater Ecology Unit