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SPATIAL DATA INFRASTRUCTURE: IMPLICATIONS FOR SOVEREIGNTY IN THE CANADIAN ARCTIC

Peter L. Pulsifer and D.R.F. Taylor

INTRODUCTION

There are many definitions of the word sovereignty, however a common usage pertains to a government possessing full control over its own affairs within a territory or geographical area.

The question of sovereignty in Canada's North is increasingly being discussed in national political discourse and the popular media. The Arctic sovereignty issue centres around access to the seas surrounding the Canadian Arctic Archipelago. Many countries including the United States assert that these ocean conduits are part of Canada's territorial sea[1] and Canada therefore must not prevent innocent passage[2] through these waters by international vessels. Canada takes the position that the waters of the Arctic Archipelago are internal waters, subject to the same control as a river or lake within the Canadian landmass. The "territorial seas" position is based in international law and specifically the United Nations Convention on the Law of the Sea (UN, 2007); the Canadian claim derives from historical use and effective occupation of the archipelagic seas.

Resolution of this issue is seen as increasingly important and urgent. An increase in ship traffic through the Northwest Passage (see fig. 1) is expected as a result of the lighter ice seasons predicted by global climate models. Moreover, changes in the environment could make development of natural resources economically feasible. In August 2006, Prime Minister Stephen Harper stated his government's view as follows:

> *It's no exaggeration to say that the need to assert our sovereignty and take action to protect our territorial integrity in the Arctic has never been more urgent.* (CBC, 2006)

For Harper the resource development issue, including possibilities of new oil and gas discoveries in the Arctic Region Basin, gives the matter urgency. He went on to say:

> *The economics and the strategic value of northern resource development are growing more attractive and critical to our nation*. (CBC, 2006)

1 The sovereignty of a coastal State extends, beyond its land territory and internal waters and, in the case of an archipelagic State, its archipelagic waters, to an adjacent belt of sea, described as the territorial sea. Every State has the right to establish the breadth of its territorial sea up to a limit not exceeding 12 nautical miles (un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm - articles 2,3).

In the public debate, some suggest that the lack of response by the United States government to these firm statements and a related increase in Canadian military activity in the North amounts to tacit acceptance of the Canadian position. If this view is correct then Canadians should focus their energies on stewardship and management of the area (Griffiths, 2006). Others, less sanguine about the acceptance of the Canadian position by the U.S. and other governments such as Denmark, suggest that Canada should adopt a "hard power" approach that includes deployment of military icebreakers and remote sensing systems for surveillance (Huebert, 2006).

It remains to be determined which of these approaches will be most effective but regardless of the approach adopted, geographic information should play a central role in any actions taken.

Historically, geographic information typically in the form of maps has played a central role in geopolitics and the establishment and management of sovereignty (Henrikson, 1999: 94–96). Maps and charts were central to "discovery" related to the territorial claims resulting in many of the world's nation states, including Canada (Morantz, 2002). Information recording the definition of boundaries that define a territory is maintained in survey records and the resulting maps. In addition, geographic information is used to describe, plan and monitor effective occupation of a territory. This perspective however is rarely explicitly stated in the current debates about Canadian sovereignty in the North.

Ultimately, supporting any particular course of action around sovereignty in the North will require adequately precise, accurate and current geographic information that goes beyond demarcation of boundaries. A modern system will, for example, need to include "real-time" monitoring of ship traffic and provide reporting on the state of resource development and the environment. In 2007, this means an extension of traditional "mapping" programs to the development of a "Spatial Data Infrastructure"[3] (SDI). The following sections define the concept of an SDI, summarize the Canadian Geospatial Data Infrastructure program, and discuss the way forward for the development of a SDI for the Arctic Circumpolar region.

THE ORIGINS AND NATURE OF SPATIAL DATA INFRASTRUCTURE

Prior to the 1960s, the primary device for storing and portraying geographic information was the paper map. Today, the paper map is still a very important mechanism for conveying geographic information. However, the 1960s brought a revolutionary change in our capacity to store, analyse, and portray geographic information. In 1964 the modern Geographic Information System (GIS) was invented at the Canadian Department of Energy, Mines, and Resources (now Natural Resources Canada). GIS supports creation, storage, and analysis of geographic information (*e.g.,* overlay, measurement, buffers) in digital form. Today, GIS is a standard tool used in many applications including land management, scientific research, archaeology, urban planning, sales and marketing, and map production.

The increasing use of GIS throughout the 1970s and 80s produced large stores of digital geographic information. Sharing the data between producers, users, and other stakeholders proved quite difficult, as most GIS data were stored in proprietary formats that could not be used by other systems. Where data sharing was possible, the lack of established networks required that the data be copied from one system to another. This introduced a number of challenges in maintaining databases including redundancy, currency, storage costs, and lack of data identification and stewardship, as often there was not a single data producer and maintainer, as was the case with paper maps.

Thus, the 1990s brought about a movement that focused on coordinating the process of geographic data production with the goal of improving geographic

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2 The United Nations Convention on the Law of the Sea defines Innocent Passage as follows: Passage is innocent so long as it is not prejudicial to the peace, good order or security of the coastal State. Such passage shall take place in conformity with this Convention and with other rules of international law (un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm - article 19).

2. *Passage of a foreign ship shall be considered to be prejudicial to the peace, good order or security of the coastal State if in the territorial sea it engages in any of the following activities:*

(a) *any threat or use of force against the sovereignty, territorial integrity or political independence of the coastal State, or in any other manner in violation of the principles of international law embodied in the Charter of the United Nations;*

(b) *any exercise or practice with weapons of any kind;*

(c) *any act aimed at collecting information to the prejudice of the defence or security of the coastal State;*

(d) *any act of propaganda aimed at affecting the defence or security of the coastal State;*

(e) *the launching, landing or taking on board of any aircraft;*

(f) *the launching, landing or taking on board of any military device;*

(g) *the loading or unloading of any commodity, currency or person contrary to the customs, fiscal, immigration or sanitary laws and regulations of the coastal State;*

(h) *any act of wilful and serious pollution contrary to this Convention;*

(i) *any fishing activities;*

(j) *the carrying out of research or survey activities;*

(k) *any act aimed at interfering with any systems of communication or any other facilities or installations of the coastal State;*

(l) *any other activity not having a direct bearing on passage.*

3. Also known as a Geospatial Data Infrastructure.

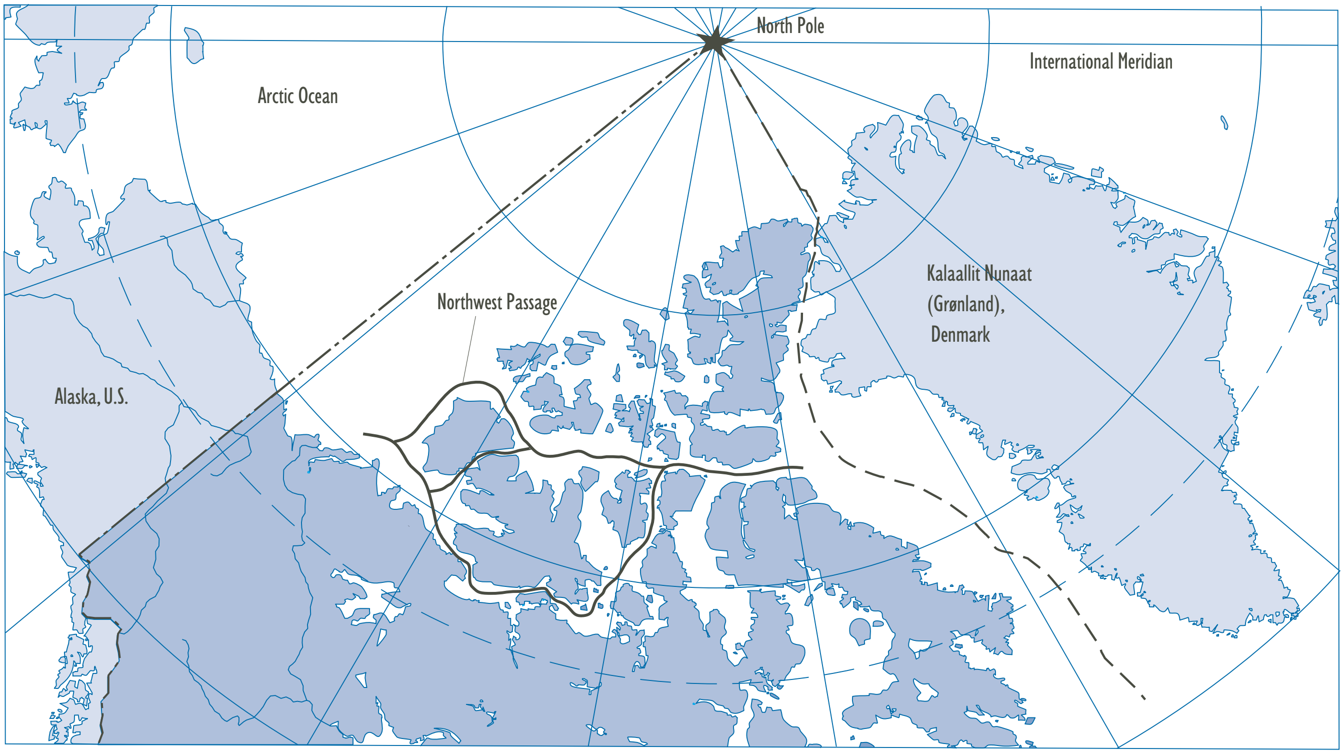

Figure 1
The Northwest Passage: territorial sea?

data and the effectiveness of its use. This movement has evolved into the concept of a Spatial Data Infrastructure (SDI). An early formal definition of SDI came from the U.S. Government:

> *National Spatial Data Infrastructure [NSDI] means the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilisation of geospatial data*. (USA, 1994)

The initial focus of SDI programs was to coordinate geographic data production efforts, including the effective cataloguing of the data. In the early to mid-nineties, the internet was being used to discover data using these new catalogues, however the data was typically distributed on CD-ROM or other similar media. This approach started to address the inefficiencies, data identification, and stewardship, but not the issues of incompatible formats, redundancy, currency, storage costs, etc.

The internet, combined with the development of new technologies and standards, has transformed SDI to its modern but still evolving form. Modern SDI programs use the internet and browser-based technology to discover datasets, visualize the data online and, if appropriate, access the data either through download or by direct connection using an internet data service. This model supports the real-time combination of data from many different sources. Each data resource is published and maintained "closest to the source", ideally the original creators. The model includes both "top-down" and "bottom-up" approaches. Larger government bodies produce what are known as framework layers, such as topographic data, while individuals or communities can publish data about more local phenomena such as wildlife sightings and the current state of the environment.

While all of these data resources may have existed prior to the conceptualization or implementation of SDIs, the SDI provides an innovative framework for integrating data so that it can be used to create application-specific information and knowledge. When considering the information requirements related to good government and sovereignty in the Canadian North, an SDI has the potential to provide a valuable framework for fulfilling these requirements. The SDI can facilitate the institutional, technical, and social networks required to generate and access the following kinds of data relevant to sovereignty including:

- territorial (demarcation of boundaries);
- operational (ship traffic, sea ice extent);
- effective occupation (hunting and fishing areas, sea ice usage);
- state of the environment (pollutants, species distribution);
- predictive models (climate, operational, economic).

It is important to note that an SDI as described here is not limited to a particular geographic scale, nor is it driven solely by a particular level or department of government. The concept centres around the establishment of a multi-participant human network that can create and sustain a multi-scale information network. In this concept, a local contribution such as a geographically referenced entry in a personal "blog"[4] can be as important as inclusion of a region-wide predictive model. Both contribute to characterizing and understanding the physical-social environment.

Canada has been a leader in the development of SDI theory and practice. This activity has resulted in the formation of a National SDI called the Canadian Geospatial Data Infrastructure.

DEVELOPMENT OF THE CANADIAN GEOSPATIAL DATA INFRASTRUCTURE

Just as Canada is internationally known as the implementer of the world's first GIS as discussed above, it is also recognized as one of the first countries to implement a Spatial Data Infrastructure. Discussions about establishing a national SDI for Canada began in the early 1990s and the concept progressed to the point that a federal program to develop a national SDI received funding in 1999. The GeoConnections program is a national partnership program established to evolve and expand the Canadian Geospatial Data Infrastructure (CGDI). The goal of CGDI is to provide Canadians with on-demand access to geographic information (*e.g.,* maps, satellite images) and related services and applications in support of sound decision making. The CGDI's four key components national framework data, common data policies, technical standards, and enabling technologies interoperate to support this goal.

4. Blog is short for weblog. A weblog is a journal (or newsletter) that is frequently updated and intended for general public consumption. Blogs generally represent the personality of the author or the Web site. A blog entry can be geographically 'tagged' (referenced) using a protocol call GeoRSS (see georss.org).

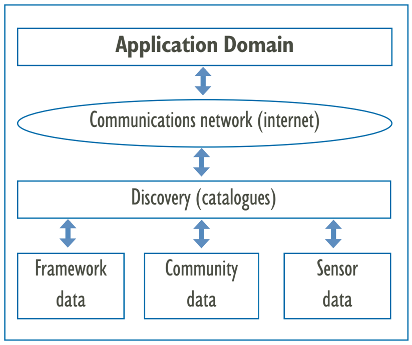

Figure 2
A conceptual model of a Spatial Data Infrastructure (SDI). The SDI supports discovery of data used in applications. Framework data is typically produced by government. Increasingly, data from communities (including communities of practice) and environmental sensors are contributing to SDIs.

The first phase of the program (1999–2005) focused on establishing framework components such as discovery services and technology. The current program, which runs from 2005 to 2010, concentrates on enabling the CGDI to meet user needs by developing applications that use the infrastructure rather than the infrastructure itself. For more information about the GeoConnections progam and the CGDI, please refer to the following website: www.geoconnections.org.

The CGDI stands to play an important role in the establishment of an SDI for the Canadian North.

THE WAY FORWARD: SOVEREIGNTY IN THE CANADIAN ARCTIC AND GDI

At present, there exists no clear, long-term strategy for addressing sovereignty concerns in the Canadian Arctic – although the current government appears to be adopting a "hard power" approach that would comprise a strong military presence combined with effective occupation. As an alternative, there have been suggestions that the Antarctic Treaty System could be used as a model for dealing with territorial claims as well as resource and environmental management in the Arctic (Ibbitson, 2006; Nowlan, 2001). In this model, territorial claims are set aside – they are neither recognized nor denied. Integrated resource management and environmental protection fall under a policy and legal regime established under an environmental protocol to the Antarctic Treaty and other treaty instruments.

These mechanisms are proving effective in managing various facets of Antarctic geopolitics and environmental stewardship. The system recognizes the value of a well-developed data infrastructure supporting of the treaty system and scientific research. In the Antarctic region, the development of data infrastructure (including Spatial Data Infrastructure) is carried out by a number of organizations and programs including the Antarctic Treaty Secretariat (www.ats.aq), the Joint Committee on Antarctic Data Management (www.jcadm.scar.org) and the Antarctic Spatial Data Infrastructure (www.antsdi.scar.org). Increasingly, these organizations are cooperating to develop a comprehensive and integrated data infrastructure for the Antarctic region.

A similar infrastructure could provide great benefit to the Arctic region. Regional projects are already being developed. As part of the *GIT Barents* Project, Russia, Finland, Sweden and Norway have cooperated to establish a joint geographic infrastructure in the Barents Region (www.gitbarents.fi). From existing national databases, this project has created a homogenous geographic database covering the entire Barents Region at the scales of 1:1, 1:3 and 1:12 million. The results are distributed using an internet-based infrastructure that allows for easy access and use of the information. At the same time the system allows for efficient updating and maintenance of databases close to their source, *i.e.,* from within each of the cooperating countries. The chosen technology allows the user to view a combination of geographic and thematic data, satellite imagery with added geographic features such as roads, railways, settlements, and hydrography etc. The approach used is similar to the INSPIRE project recently approved by the European Union to create a seamless SDI for all of Europe (www.ec-gis.org/inspire).

Similarly, the Canadian government has developed many arctic geospatial data infrastructure elements through Natural Resources Canada's GeoConnections program and the Canadian Geospatial Data Infrastructure as well as priority programs such Geomatics for Northern Development (www.ess.nrcan.gc.ca/2002_2006/gnd/index_e.php). Local stakeholders are also developing resources. The Government of Yukon has a well-developed Geomatics program (www.geomaticsyukon.ca). Planning Organizations like the Yukon Land Use Planning Council have developed an on-line atlas that includes geospatial analysis tools (www.planyukon.ca). These initiatives, along with community-based projects, can contribute to an SDI that can be used to develop information and knowledge in support of good government and good management of Canada's North – and will also assist Canada in dealing with sovereignty issues.

Currently, there is no coordinated Geospatial Data Infrastructure program focused on the North and the Arctic at a national level or for the region as a whole. Many of the elements required already exist, but effective coordination is missing. Here governments at the federal, provincial, territorial, and local levels can all participate in creating the infrastructure, as can individual communities and citizens. International organizations such as the Arctic Council can also play an important role. With the International Polar Year now under way the collaborative aspects of SDI development may well be facilitated by ongoing activities such as the IPY GeoNorth 2007 conference (ess.nrcan.gc.ca/ipygeonorth/index_e.php). This conference aims to bring the key national players for the Arctic Basin round the table to discuss potential joint action. The logic of ensuring that an infrastructure created by Canada is at least interoperable with the one created by the northern nations of Europe is very strong. Canadian leadership in this respect would be an important symbol in terms of our assertion of sovereignty.

Like the Antarctic, the Arctic is a region where sovereignty issues are a concern, scientific research activity is high, and pressure is increasing to develop resources. Unlike the Antarctic, the Arctic region is home to many tens of thousands of permanent residents. The way we manage sovereignty concerns and environmental stewardship will therefore significantly affect the lives of many. An effective Geospatial Data Infrastructure can contribute to successful stewardship by helping to establish constructive solutions for sovereignty issues and for sound management of resources and the environment.

Peter L. Pulsifer (Ph.D. candidate) and D.R.F. Taylor (Distinguished Research Professor) are both with the Geomatics and Cartographic Research Centre, at the Department of Geography, Carleton University.

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USING LAKE SEDIMENTS TO RECONSTRUCT ENVIRONMENTAL CHANGES IN THE ARCTIC

Marianne S.V Douglas and John P. Smol

Arctic latitudes are showing clear evidence of rapid environmental change. In November 2004, the *Arctic Climate Impact Assessment* (ACIA, 2004) was released by the Arctic Council. Made up of the eight circum-Arctic nations, the Arctic Council was partly responding to the observations voiced by concerned citizens that high latitude environments were changing rapidly and with often detrimental effects for the people and wildlife whose survival is so tightly tied to the land. These changes are clearly being observed by people living in the Arctic; however long-term trends on environmental changes are difficult to document due to the lack of historical records for many polar regions. Fortunately, a variety of paleoenvironmental records are available to extend the period of instrumental data. This article summarizes some of the paleolimnological research focused on describing the extent and impact of warming and related environmental changes in the Canadian Arctic.

The *ACIA* documented numerous changes in the Arctic environment, such as melting glaciers, thinning and receding sea ice, longer summer seasons, melting permafrost, rising sea levels, expansion (and some subsequent contraction) of biogeographical ranges for animal and plant species, increased exposure to ultraviolet radiation as a result of stratospheric ozone depletion, as well as the transport of pollutants such as persistent organic pollutants (POPs) and metals (*e.g.,* mercury) from more southern latitudes to the Arctic via rivers, ocean currents, and winds. The cumulative impacts of these numerous changing factors are likely synergistic (*i.e.,* additive) and, although difficult to measure directly on long time frames, are known to have negative impacts on ecosystems.

Assessing the extent and nature of environmental change can be difficult, as the degree of change is often a relative measure. Given the range of natural variability within ecosystems, it is necessary to put the observed changes in the correct temporal and spatial contexts with baseline data. For example, in order to assess whether average temperatures are rising (or cooling) it is necessary to have a long time-series of temperature measurements (or some other proxy of climate). In the Arctic, where the instrumental temperature record is short, mostly less than 50 years, it is difficult to obtain this information solely from instrumental measurements. Fortunately there are many ways to obtain proxy *(i.e.,* substitute) records for these missing data which can be used to determine the timing and magnitudes of past environmental changes. A variety of natural environmental archives can be used for tracking long-term environmental changes, although ice sheets and ocean and lake sediments are the most commonly used sources in Arctic regions. For example, ice cores drilled from polar ice sheets provide a wide spectrum of paleoenvironmental information, including trapped air bubbles

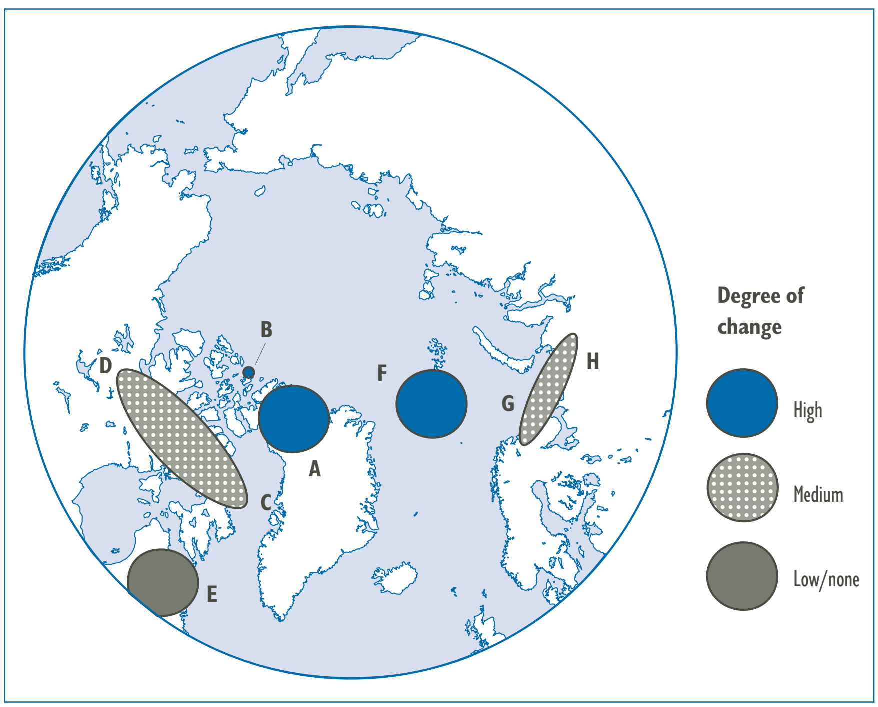

Figure 1
Circum-Arctic projection showing the degree of recent change in diatom assemblages in lake sediments since the early 1800s. Site locations A–H represent locations where paleolimnological analyses were conducted.
A: Ellesmere Island;
B: Ellef Ringnes Island;
C: Baffin Island;
D: Northwest Territories;
E: Northern Quebec;
F: Spitzbergen;
G: Finnish Lapland;
H: Polar Urals.
For further details refer to figure 1, Smol *et al.*, 2005.
Modified from Smol *et al.* (2005).

from which measurements of past atmospheric conditions can be measured, as well as records of past pollutants and climatic changes. In addition, sediment cores retrieved from ocean and lake basins provide additional archives of past environments, as microfossils and other indicators preserved within the mud matrix contain information regarding the environment at the time of deposition. The study of lake sediments, also known as paleolimnology, has proved to be a valuable and powerful tool in reconstructing past environmental conditions in polar regions (Pienitz *et al.,* 2004). In fact, readers of *Meridian* can refer back to the article by Wolfe *et al.* (2006) who used similar techniques to reconstruct past aquatic environmental conditions in the Peace-Athabasca delta ecosystem.

Dramatic environmental changes in lake sediments that could be linked to recent climatic warming were first reported from the east-central coast of Ellesmere Island in the mid-1990s (Douglas *et al.,* 1994). By studying algal microfossils called diatoms from the sediments of shallow ponds, it was shown that the freshwater ponds at Cape Herschel experienced unprecedented shifts in algal community structure, and that these were likely the result of warming. Diatoms are excellent microfossils to use in paleolimnological analyses as their cell walls are made of glass and so they preserve well in the sediments. Different species, which can be identified based upon the ornamentation of their sculpted glass cell walls, are characterized by different ecological optima. Hence, when identified in sediments, the environmental conditions at the time of deposition can be inferred based upon the diatom species present.

On Ellesmere Island, the diatom assemblages revealed surprising results: for over several thousands of years, only a handful of species had thrived. However, beginning in the 1800s, that assemblage had been replaced by one with higher diversity and with species indicative of warmer environments. Using radiometric dating techniques, such as ^{210}Pb, it was possible to determine the approximate timing of the change. Surprisingly, the assemblage change had occurred very quickly, likely in the period of less than a decade. An ecological threshold had been passed. Arguments that these species changes might have been caused by pollution, ozone depletion, poor microfossil preservation or coring artifacts could be discounted (Douglas *et al.,* 1994). Subsequent study of the present-day freshwater diatoms living in the Canadian Arctic revealed that the species inhabiting the ponds before the more recent changes took place were taxa characteristic of colder, more ice-covered environments. The timing and magnitude of the change indicated that a warming Arctic was likely related to these marked assemblage shifts (Douglas *et al.,* 1994).

Figure 2
A short gravity core taken from a Cape Herschel pond, on Ellesmere Island. Photo: M.S.V. Douglas.

Over the course of the decade following the initial 1994 study, numerous researchers reported similar paleolimnological findings throughout the circum-Arctic. Not only were diatom assemblages across the Arctic showing similar trends, but similar concomitant shifts were being recorded in indicators higher up the food chain, such as by chironomid insects (Quinlan *et al.,* 2005) and other zooplankton, such as Cladocera. A meta-analysis of over 40 sediment profiles from across the circumpolar Arctic showed striking trends in many lakes and ponds (Smol *et al.,* 2005). Although the timing and magnitude of the environmental shifts varied according to geographic location (as expected from such a heterogeneous environment), several noticeable trends were observed. In general, the greatest shifts in species turn over were observed at the highest latitudes in the most sensitive (shallowest) sites, whereas less striking shifts were observed at lower latitudes (fig. 1). Regions which had not experienced similar magnitudes of warming (at the time of these studies), such as northern Quebec and Labrador, did not record significant shifts in diatom assemblages (fig. 1). Paleolimnological analyses provided a powerful and reliable means by which to track environmental changes.

Many of the environmental changes observed in the Arctic will likely be magnified as a result of cumulative impacts. For instance, the deposition of pollutants in the north may be accelerated and their effects exacerbated as a result of warming conditions. A large spectrum of persistent organic pollutants, for example, is transported to polar regions via air and water currents. However, once again, it is difficult to determine the history of deposition patterns of these pollutants without turning to the sedimentary record (Blais and Muir, 2001). One new area of research is the biotransport of contaminants via biological vectors (Blais *et al.,* 2007; Evenset *et al.,* 2004), such as sea birds. To use a recent Canadian example, Blais *et al.* (2005) examined the surficial sediments from several ponds on Devon

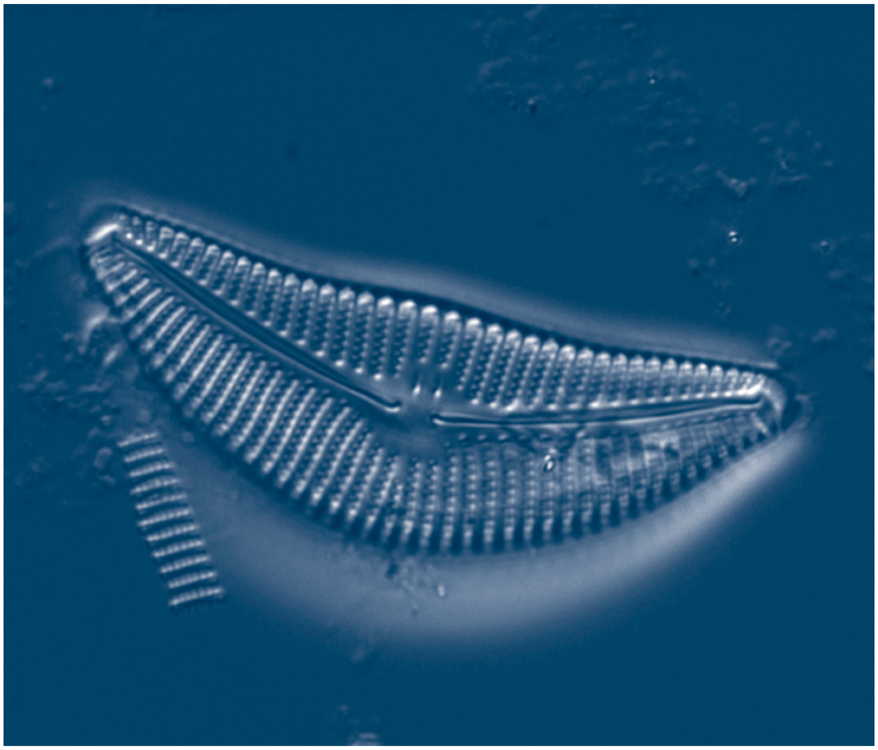

Figure 3
A diatom belonging to the genus Cymbella. Photo: Dermot Antoniades.

Island affected by different degrees of nesting bird influences. They showed that sediments sampled closest to the source of the nesting birds had the highest levels of contaminants. In order to determine the timing and rates of contaminant deposition in this area, sediment cores are now being examined to provide a temporal perspective for these contaminant studies (study in progress).

Although many environmental changes have been noted by people living in the North, these indicators are largely macroscopic, *i.e.,* the conclusion is based upon changes that can be readily observed, such as the range extension of various birds and insects, the reduction in sea ice thickness and extent and so forth. In order to extend the monitoring window back in time, however, we have to dovetail these observations with proxy data preserved in geological records, such as paleolimnology.

Marianne S.V. Douglas is Director of the Canadian Circumpolar Institute and Professor in the Department of Earth and Atmospheric Sciences at the University of Alberta. John P. Smol is Professor in the Department of Biology at Queen's University and a Fellow of the Royal Society of Canada. He holds a Canada Research Chair in Environmental Change.

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ARCTIC AQUATIC ECOSYSTEM RESEARCH: PRESENT AND FUTURE

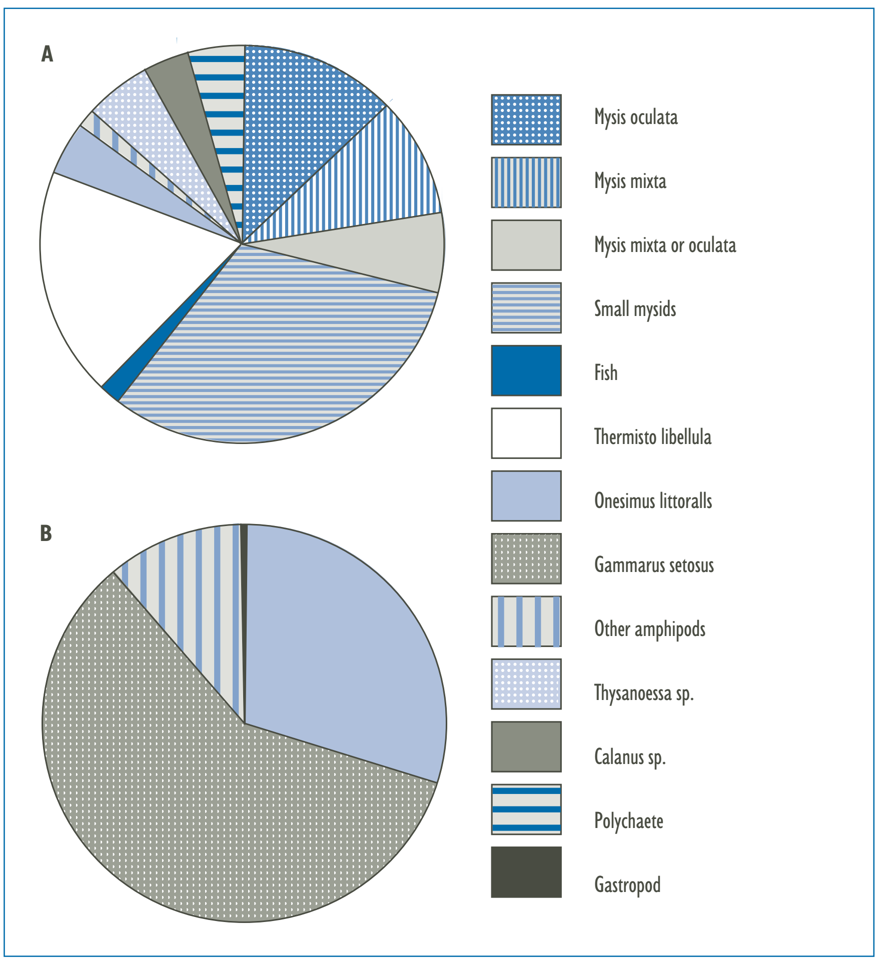
Terry A. Dick and Colin P. Gallagher

INTRODUCTION

Global warming and resource extraction will both have major impacts on arctic aquatic ecosystems, and substantial baseline data is still needed on most of these systems. Much of our research deals with freshwater and marine ecosystems, particularly food webs and trophic feeding of fish. As we discussed the importance of arctic marine fish food webs in a previous *Meridian* article (Dick and Chambers, 2005) it will not be presented in detail here. However, based on our research to date, some general conclusions can be made: arctic marine food webs appear to be a continuum with loss of species northward (Chambers and Dick, 2006); the physical oceanic variables can be correlated with fish species distribution (Jorgensen *et al.,* 2005; Chambers and Dick, 2006); and the traditional guild approach to describe trophic structure of fish communities does not appear to adequately describe arctic marine systems (Chambers and Dick, 2006).

This report deals with the results of research in arctic estuaries, freshwater lakes, and streams, from the viewpoint of energy sources and habitat use by fish. It also discusses our collaborations with Nunavut Arctic College.

Figure 1
Percent frequency of food items in Arctic char from the A) Sylvia Grinnell River and B) shorthorn sculpin from Peterhead Inlet and Sylvia Grinnell River.



INSHORE AND ESTUARY FISH COMMUNITIES

The inshore and estuary arctic char subsistence fisheries are important to many arctic communities (Dick and Chambers, 2005). While there is some information on the status of the fish stocks in these areas there is much less on the inshore fish community with respect to habitat use, competition – both intraspecific (between fish of the same species) and interspecific (between fish species) – and on fish/environment interactions. We have completed a series of studies on two of the most important fish species in the inshore area of Frobisher Bay near Iqaluit. These have evaluated the biology, growth, food habits, parasites and stable isotopes of arctic char (*Salvelinus alpinus*) and shorthorn sculpin (*Myoxocephalus scorpius*) to establish baseline information prior to the anticipated influences of global warming.

Anadromous arctic char obtain most of their energy during the short arctic summer while feeding in the ocean in the pelagic (open water) zone. Shorthorn sculpin remain in the ocean year-round and obtain their food mostly in the benthic (ocean bottom) zone. Our data so far shows that overlap in energy requirements and interspecific competition is low between char and shorthorn sculpin (fig. 1) but we predict that alien species invasions will lead to more competition for food and space.

A predictive energy model for fish in changing arctic marine systems requires assessment of the energy costs for basic metabolic needs and growth, as well as methods to determine linkages between physical changes in the marine environment and biota, including fish behaviour and feeding patterns. We are building on our current data on growth, energy inputs, and

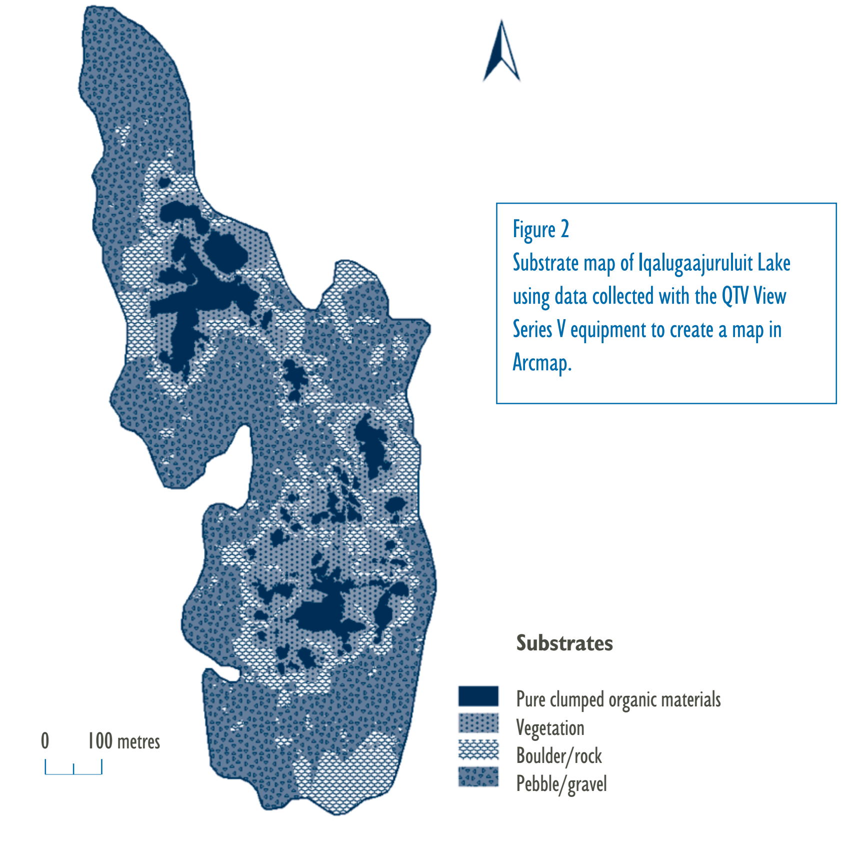


Figure 2
Substrate map of Iqalugaajuruluit Lake using data collected with the QTV View Series V equipment to create a map in Arcmap.

food quality, where we have determined the total energy content of food and completed proximate analysis (chemical analysis of the main constituents of food) on key food items.

The energy model will apply to inshore estuarine fisheries throughout the Arctic. It should eventually be able to evaluate food (energy availability), competition (invasion by alien species) and impact of changes in abiotic variables (temperature, salinity, oxygen, currents) on fish movements. We hypothesize that the way fish respond at the local scale to changing environments such as tides – where salinity and temperature can change by the hour – will have direct relevance to the open ocean, where physical changes from global warming will occur more slowly. Furthermore, the preferred temperature and salinity is directly relevant to our energy models for fish growth and time to reach sexual maturity. We also hypothesize that while there is little competition for food today, when alien species arrive they will compete for food and space with arctic char – which is a poor competitor and will likely lose out. Food is important to optimal growth, but char's interactions with the physical environment will also be crucial to assuring its future success in the marine environment.

New research tools – long-lived acoustic tags and long-lived remotely downloaded receivers – have been developed to aid studies of fish movements. These, combined with the ability to record the habits of an individual fish, will allow major advances in understanding how a fish interacts with its environment, in real time. We have tested these tools in freshwater systems, for arctic char in Iqalugaajuruluit Lake on Baffin Island, and with lake trout (*Salvelinus namaycush*) in Chitty Lake, NWT, using acoustically tagged fish with sensors that can measure location, depth, and water temperature. Other acoustic technologies are used to map lake depth and the substrate types on the lake bottom (fig. 2). Figure 3 shows the diurnal movements of lake trout under the ice in Chitty Lake (Dick *et al.,* 2005). This movement is related to photoperiod and feeding.

FRESH WATER SYSTEMS

Small arctic lakes are generally considered to be nutrient-poor environments with simple fish communities, and the most widely distributed species is arctic char, regardless of lake size. Moreover, most arctic lakes are small with high volume-to-area ratios and are less likely to be dominated by one habitat type (see map of substrate in Iqalugaajuruluit Lake, fig. 2). Although lake systems are often studied as separate entities – the pelagic, benthic and riparian (shoreline) habitats – there are strong linkages among them (Schindler and Scheuerell, 2002). We hypothesize that these small arctic lakes are coupled by physical, chemical, and biological processes and that fishes reveal connections across habitat types.

We have studied trophic structure (the pattern of eating in an ecosystem) in small arctic lakes by describing the interactions of arctic char and ninespine stickleback to determine the sources of the energy going into the lake and the flow of that energy through the fish community. These studies include the type of food consumed, parasites (indicators of food consumption since some parasites are transmitted through food and, as pathogens, may be population regulators) stable isotopes as indicators of food consumed, and the interaction and movements of arctic char with its physical environment.

Despite a substantial published literature on the use of stable isotopes to describe trophic structure of fish communities, interpretation is problematic: more controlled experiments are needed to determine the factors affecting stable isotopes ratios of carbon and nitrogen (Hesslein *et al.,* 1993). A series of laboratory experiments were designed to determine the time to reach a new half-life for a stable isotope and a new equilibrium after a diet switch, using young-of-the-year arctic char. Stable isotope ratios for $\delta^{13}C$ and $\delta^{15}N$ reached equilibrium as early as the 56th day after the first feed. The half-life of $\delta^{15}N$ isotopes were calculated at 43.4 and 32.3, and for $\delta^{13}C$ half-life at 24.6 and 29.0 days for char fed diets of blood worm and frozen adult brine shrimp, respectively. The time to reach the half-life and new stable isotope equilibrium was related to growth, with the young fast-growing char having the shortest half-life. Young-of-the-year char that did not grow but maintained their initial body weight throughout the growth trial had calculated half-lives for $\delta^{13}C$ and $\delta^{15}N$ at over 700 days (Isinguzo *et al.,* 2006). We agree with Hesslein *et al.* (1993) that old slow-growing fish may take several years to reach new stable isotope equilibrium if the diet is switched, but the nutritional state of an individual wild fish is equally important to its trophic status. Furthermore, proximate analysis, stable isotope, and growth data from diet-switching experiments suggests that the absolute amount of fat and the relative amount of fat to protein may be important in predicting the time it takes to shift to new stable isotope equilibrium, especially for cold water species. Caution is clearly required when using stable isotope to describe trophic structure and natural food webs in aquatic systems where little other biological data is collected.

As char eat mostly benthic invertebrates when in freshwater arctic lakes, zooplankton is generally considered of minimal importance as an energy source. Our data indicates that zooplankton is an important food source for ninespine stickleback, which is in turn consumed by char – indicating habitat coupling. Furthermore, our data and that of Karlsson and Bystrom (2005) indicate that the littoral zone is a key source of

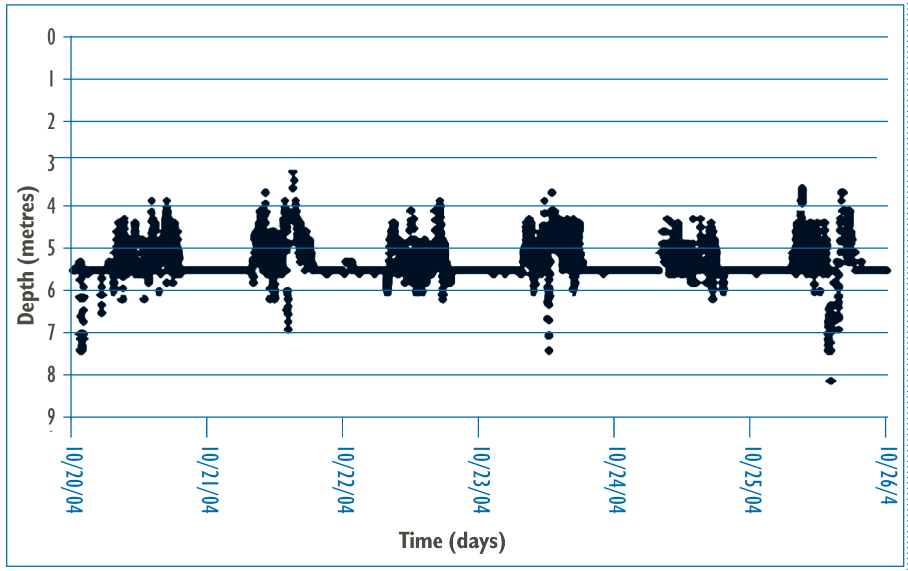


Figure 3
Diurnal movements of lake trout fitted with a Vemco pressure tag and data collected under the ice with a Vemco VR2 receiver.

Figure 4
Students from Nunavut Arctic College preparing data logger to monitor temperature and pressure (depth) over a tidal cycle. A) enlargement of a data logger. Photo: T. Dick.

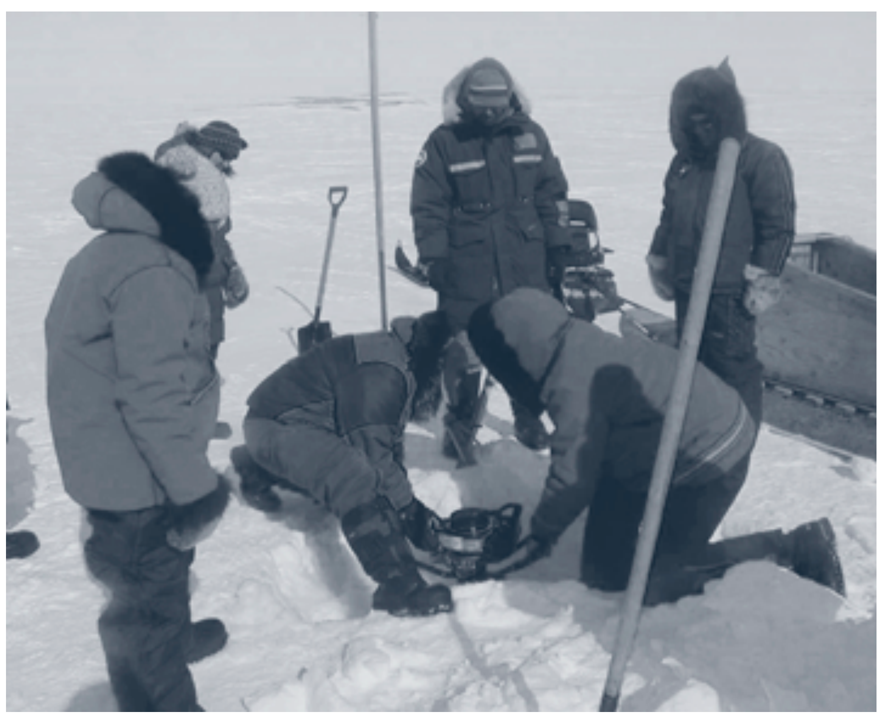
energy input to these small lakes and this inshore habitat is coupled with the pelagic habitat through fish movements and feeding. Piscivory (eating other fish species) and cannibalism by large char is an important use of energy in the lake. Our data on char movements and habitat mapping studies indicate that large char make extensive use of a small portion of the lake correlated with temperature and depth. We speculate that this unique area – 3.3% of total lake volume – may become limiting habitat for arctic char if warmer summers reduce the extent of cooler water with adequate oxygen in these small lakes (Dick *et al.,* 2006).

The way in which landlocked char interact with their lacustrine habitat is not well known. To document arctic char movement we collected acoustic data from the lake bottom using sonar-based hydrographic survey (QTCVIEW Series V) to determine substrate types and to map these substrates in a Geographic Information System (GIS). We gathered data on char movements during the open water period by underwater acoustic telemetry, collecting data from acoustically tagged fish with strategically placed VR2 receivers (VEMCO). To increase the resolution of the acoustic tagging, we carried out system multivariate analysis (CCA) to show that the detection of char by different acoustic receivers was aggregated and therefore localized in the lake (Dick *et al.,* 2006).

In Iqalugaajuruluit Lake the distribution of tagged char depended on the size of the fish and was related to abiotic factors such as substrate type, depth, and water temperature. Large char (over 400 mm) may be limited to areas colder than 6°C during the open water period in small arctic lakes. The char distributions appear to be related to feeding types: large piscivorous char are found most often in the deepest water over soft substrates while smaller char, which feed on invertebrates and fish, are most common over boulders, pebbles and gravel.

Figure 5
Students from Nunavut Arctic College using a portable acoustic flow meter to measure current across a stream bed so that total stream flow can be calculated. Photo: T. Dick.

Figure 6
Students from Nunavut Arctic College using ice auger to prepare opening for zooplankton collections and in situ physical readings during the Environmental Technology Program winter field course. Photo: T. Dick.



EDUCATION

We work closely with the Nunavut Arctic College, incorporating our research findings into the teaching program to cover such topics as fisheries management, marine

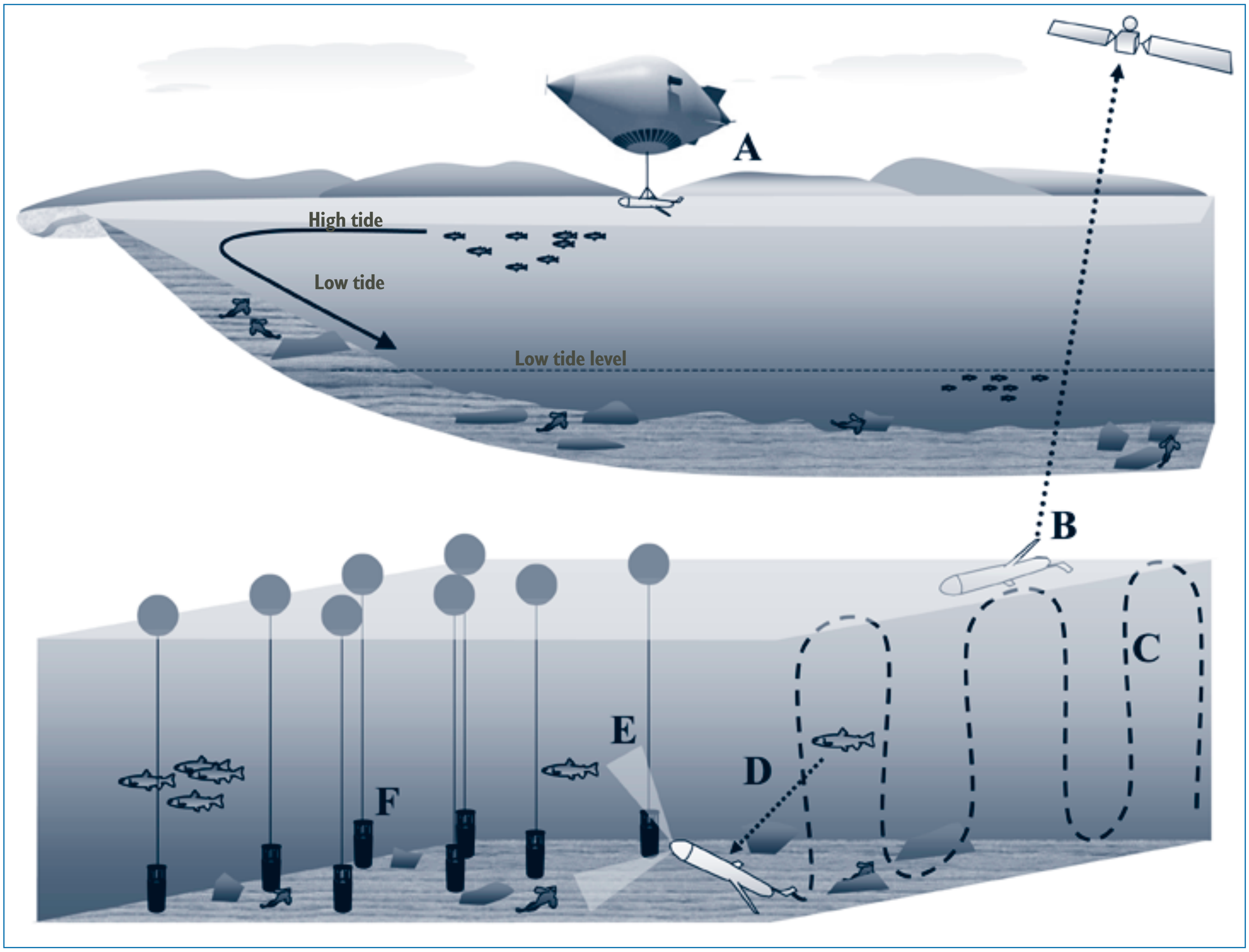


Figure 7
Future studies on fish/environmental interactions. The collection of data using passive receivers is time-consuming, and since large numbers of receivers are required, due to the limited detection range, costs are high. The mobile dive glider simultaneously collects data on physical variables in the ocean and on the location of tagged fish. The dive glider is programmable, allowing repeated passes over an extended area, under the ice, at the floe edge, and in remote areas where data can be transferred to satellites. The airship allows access to remote locations year round enabling deployment of the glider to polynyas in the winter, to any location during ice breakup, and at the ice floe edge at any time of year.

A: Airship deploying a dive glider.
B: Transferring data from dive glider to satellite and correction of dive glider position by GPS.
C: Sensors in the dive glider record temperature, pressure, salinity and oxygen as it moves through a programmed path in the ocean.
D: Downloading data on pressure, temperature and location from acoustic tags implanted in a fish.
E: Detection of fish by direction and distance from dive glider.
F: Passive detection system to verify accuracy of fish detected by the dive glider.

biology, stream ecology and limnology. Students during the fall field camp at Peterhead Inlet collect physical data from the ocean using data loggers (fig. 4) and assess and monitor stream ecology as it relates to substrate, stream flow (fig. 5) and identification of stream biota. Methods have been standardized so that each class collects the same data. The objective is to combine our research interests in juvenile fish habitat and food availability in streams with the establishment of long-term arctic stream reference data sets that reside at Nunavut Arctic College and the Nunavut Research Institute.

Through the winter field teaching program at Nunavut College (fig. 6) we have developed ways to keep equipment operational and collect data at very low temperatures. In lectures we discuss our data from the small lakes on fish community structure, trophic feeding, char movements (fig. 3), substrate mapping (fig. 2) and energy flow.

FUTURE RESEARCH

One aspect of our future research deals with fish/environmental interactions. Initial studies will be done in the Iqaluit area as it is readily accessible, college students are available, and knowledge can be transferred quickly to the college and the community as a whole. We will use passive acoustic receivers as well as mobile dive gliders (fig. 7). Initially, acoustic receivers will be set up in a grid to detect small-scale fish movements (5–10 km) and record local hydrographic data. Focusing on arctic char and shorthorn sculpin, we aim to determine how fish respond to tidal movements, where they feed in the water column, their location relative to temperature and salinity gradients as tides rise and fall; and whether fish movements are largely passive or whether there is an energy cost associated with tidal movements.

This research will take place in the marine environment at depths between 5 to 30 m. The initial studies will evaluate fish movements on a coarse scale within a 100 km^2 area. This will then be reduced to 1 km^2 areas as key activity sites are located, especially for the shorthorn sculpin. Substrates will be mapped using the QTCVIEW series V (fig. 2).

Data will be collected simultaneously from passive receivers and a dive glider (fig. 7). Two hydrophone ports will be placed into the dive glider, which is a mobile unit capable of moving to specific locations and depths occupying controlled spatial and temporal grids. Powered by alkaline batteries and programmable, this versatile and manoeuverable device can carry customized sensors and operate for 15 to 30 days at a time (fig. 7). It positions itself by dead reckoning, periodically surfacing to correct its location by global positioning system (GPS).

Individual char movements will be measured in the estuary at Iqaluit and at the same time physical data will be collected from the environment. The glider will record temperature, conductivity, depth, oxygen, and current, both vertically and horizontally, with high resolution. The dive glider will initially operate during 12–24 hour intervals to coincide with the tide cycle, after which data will be downloaded and the batteries changed.

This data on fish movements will provide information on areas of highest fish activity by both species. Research will then focus on fine-scale interactions of the fish with their environment in these areas, including movements of male and female shorthorn sculpin around the brooding areas (nests), the vertical movements of Arctic char in the water column as tides change, and the questions of what the two fish species feed on during the tidal cycle, when, and where.

This research will of course enable us to field-test equipment, but it will also add to our understanding of energy budgets for fish movements during daily and seasonal tidal shifts, energy costs to protect offspring by sculpins, and energy costs associated with predator avoidance. It will also reveal how fish respond to changing physical variables in the ocean. The data, when combined with information on the total energy of the food consumed and food item quality (proximate analysis), will form the basis of new energy models to predict the responses of marine fishes to large-scale environmental changes.

Terry Dick is Professor in the Department of Zoology, University of Manitoba, and Natural Sciences and Engineering Research Council Northern Chair. Colin Gallagher is a senior research technician with extensive Arctic experience.

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CANADIAN BOREAL FOREST DYNAMICS IN A TIME OF GLOBAL CHANGE

Serge Payette

The Northern Research Chair on the Ecology of Forest Disturbances (www.chairenordique crsng.ulaval.ca) was created in 2003 with the support of the Natural Sciences and Engineering Research Council (NSERC), and in cooperation with the Kativik Regional Government, the Cree Regional Authority, the Ouranos Consortium on Climate Change, and Hydro-Quebec. The Chair focuses on the evolution of northern terrestrial ecosystem stability as it relates to natural and human-induced disturbances, in the context of past, current, and future climate changes. Activities so far have enabled the mentoring and training of master's and doctoral students in the group's two main areas of interest: the dynamics of natural and human-induced disturbances in the northern forest, and the restoration of disturbed sites in Quebec's mid-north and Nunavik.

A cooperation agreement on disturbed site restoration with the Cree Regional Authority and the east Hudson Bay Cree village of Whapmagoostui has enabled development of a plan for stabilizing and restoring damaged areas. Leading this work is Stéphane Boudreau, who was recently recruited to the Chair's academic program. He supervises Ian Boucher and Alexis Deshaies, master's students who spend a considerable amount of time in Whapmagoostui. Cree students from the village are receiving technical and scientific training as research assistants as part of the program in restoration research.

Other Chair restoration projects near Kuujjuaq have been led by Yves Bégin, director of Laval's Centre d'études nordiques. We expect to become even more involved in site restoration through the study of natural ecological succession in sites disturbed decades ago by mining activity or hydro construction.

The Kativik Regional Government, based in Kuujjuaq, has contributed part of the funding for another major multi-year project: an illustrated Flora for Quebec and Labrador north of the 54th parallel. This work will include the botanic and biogeographic descriptions of the approximately 800 vascular taxa of the region. Distribution maps for each have been developed using northern Quebec-Labrador specimens from the main herbaria of Eastern Canada and from the Gray Herbarium in Boston. The many botanists on our team have properly identified all specimens and are participating in the development of identification keys and descriptions for each taxon. Label information has been incorporated into a database of over 90,000 specimens. The Flora will have many uses in natural science including the creation of a database on the state of biodiversity, the status of vulnerable or threatened species in the region, climate change impacts, the distribution of native species, invading species, and the range dynamics of taxa sensitive to change. This project works closely with the Louis-Marie Herbarium at Université Laval.

Through the Chair we have created a diversified research program in spatiotemporal dynamics of the boreal forest, one of the planet's principal forests and certainly the most important in North America. The research is based on the hypothesis that natural disturbances – climatic changes and fire – have influenced the fundamental nature of the boreal forest over both time and space since the time of deglaciation. It is ultimately through disturbances, sometimes occurring in isolation and at other times coming all at once, that the characteristic boreal forest stands develop, thrive, alter, and disappear.

Across Canada from east to west – from Newfoundland to the Yukon – the boreal forest forms a vast biome composed of three main vegetation zones: the closed-crown forest zone, the open-crown forest zone (lichen woodland), and the tundra forest zone (fig. 1). The southernmost part of the boreal forest is in contact with the eastern deciduous forest, the central part borders on the Prairies, and the western edge touches the cordilleran vegetation of the Rockies. Its northernmost boundary, stretching from Labrador to the Yukon, is the arctic tundra.

Our research involves mainly eastern Canada, from Hudson Bay to the Labrador coast. Focusing on the origins of today's boreal forest, we are testing the hypothesis that fire was the agent of change over the last few millennia, during which climate changes also likely occurred. Fire affects the structure, botanic composition, and functioning of the boreal forest, as several researchers have demonstrated (Johnson, 1992; Payette, 1992; Stocks *et al.,* 1998; Arsenault, 2001; Bergeron *et al.,* 2004). We are looking at the origin and dynamics of the three principle zones of the boreal forest in eastern Canada through a number of basic and practical research projects. Most deal with ecological and paleoecological analysis of the forest tundra, the most northerly and coldest zone, where we have observed that the forest has been retreating for several millennia, especially over the last 1000 years.

Master's student Sarah Auger is examining the structure of millennial forests on the treeline. Here we can speak of 'gerontoecology', for these lichen woodlands –

which are virtually ignored in the scientific literature – are ancient and stable ecosystems. They are also vulnerable to the deadly mix of fire and climatic cooling, which together can destroy a thousand-year-old forest in a single blow. A catastrophic fire does not change the position of the treeline; what occurs, rather, is the systematic deforestation of the northern part of the forest zone.

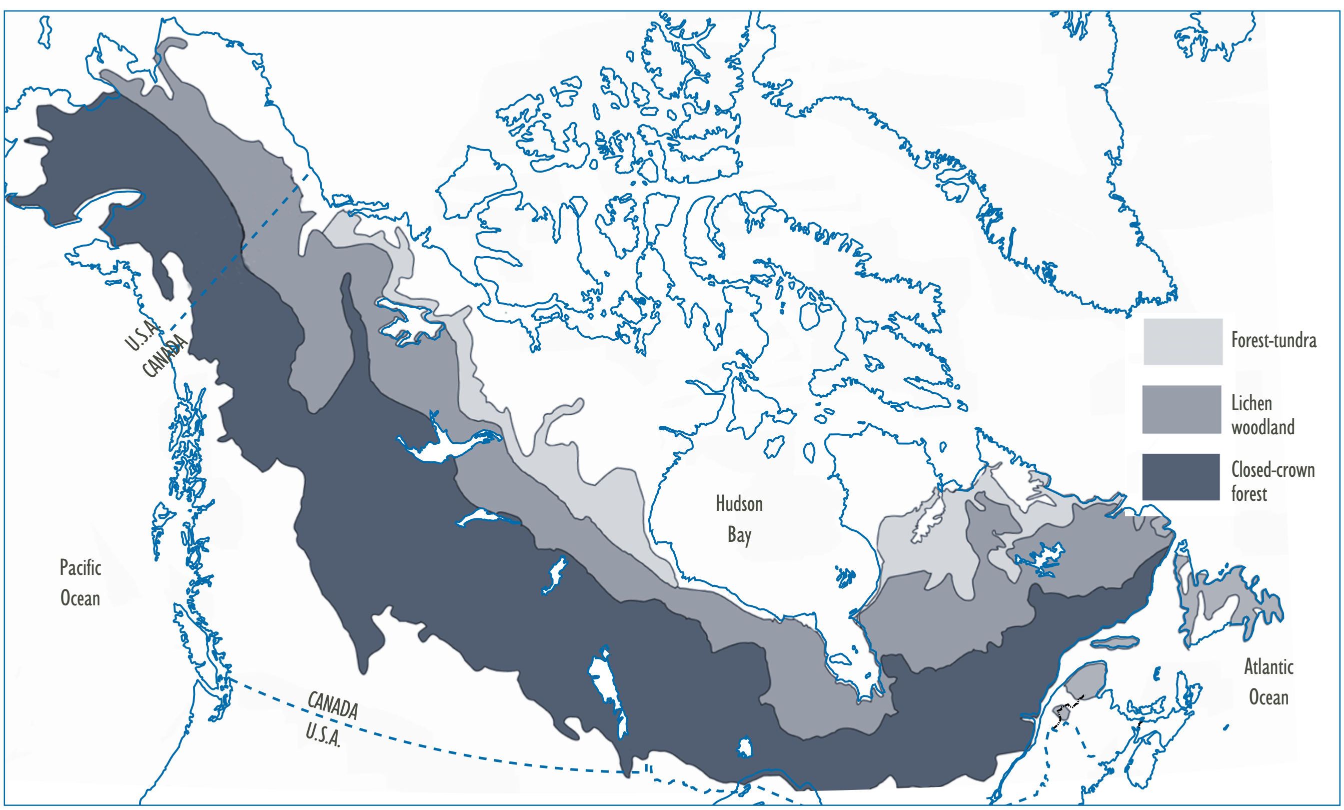
Our work on forest regeneration potential has revealed a 7% loss in boreal forest area in northern Quebec-Labrador. When depicted on a graph, loss of forest cover (forest in this case means lichen woodland) in the forest tundra zone from its southern limit (which is also the northern limit of the open-crown forest zone) to its northern boundary (the treeline) shows a logarithmic pattern: the rate of deforestation of forest tundra zone as a function of latitude is higher in the southern than the northern area. This, noted in a recent study (Payette *et al.,* 2001), led us to undertake a series of projects on the latitudinal distribution and origin of the main forests of the biome, in order to improve our understanding of the dynamics of the three principal boreal forest zones. Together, these projects represent a detailed spatiotemporal analysis of the distribution and abundance of the open-crown forest.

Using open-crown forest distribution data for the forest tundra zone (Payette *et al.,* 2001) we analysed the southern section of the lichen woodland range inside the closed-crown forest zone, which consists of feathermoss spruce forests. This research, part of François Girard's doctoral thesis (co-supervised with Réjean Gagnon of the Université du Québec à Chicoutimi), defines the distribution and abundance of the open forest from its southern limit to the open-crown forest zone proper.

In the closed-crown forest zone, abundance and distribution from south to north is the reverse of the forest-tundra pattern. Open-crown forest distribution over the entire boreal forest biome shows a bell curve, suggesting post-fire forest regeneration success. If this is correct, the gains of the open-crown forest at the expense of the closed-crown forest within the closed-forest zone illustrate the vulnerability of the closed-crown forest to fire, the most common disturbance in the boreal forest.

The origin and dynamics of the closed-crown forest is being analyzed by master's student Stefanie Pollock. Her study, twinned with François Girard's project, confirms that the closed-crown forest is shrinking. Fires in the boreal forest consume very little of the surface organic layer, which is an unfavourable environment for seed germination of black spruce (*Picea mariana*). Here again, closed-crown forest distribution and latitude follow a logarithmic relationship in the northern area, suggesting greater forest loss there.

Figure 1



We are now developing a spatiotemporal dynamic model for vegetation zones in the boreal forest biome, based on the bell-curve distribution of each zone and of its dominant stands. This model is the basis for other Northern Chair projects on the white birch (*Betula papyrifera*) – balsam fir (*Abies balsamea*) forest which is the southernmost boreal stand, found in the wet areas of the closed-crown forest zone in eastern North America, and on its main companion species, white spruce (*Picea glauca*).

A good deal of advancing and retreating went on in the boreal forest during the Holocene, as fire played havoc with the distribution of tree species. The boreal fir stand probably retreated in much the same way it does now in the closed-crown forest, its disappearance and replacement *in situ* marked by white birch groves and white spruce forests. This Holocene transition from fir stand to white spruce forest, especially in the subalpine region, is the subject of Guillaume de Lafontaine's doctoral research. His project includes a phylogeographic analysis of white spruce stands to test the hypothesis of the creation of the sub-alpine spruce forest from genetic stock originating in a source boreal fir stand. The inability of balsam fir to regenerate in the subarctic and subalpine conditions that emerged during the upper Holocene would have favoured the hardier white spruce, which, like balsam fir, reproduces sexually. The only white spruce forests in the Quebec-Labrador interior live under subalpine conditions, and as a function of altitude they are found in both the closed-crown and open-crown forest zones. Otherwise, these forests inhabit the maritime coasts: James Bay, Hudson Bay, Ungava Bay, and the Labrador Sea.

We have other projects looking at white spruce migration and expansion over the last few centuries in response to climatic changes. A post-doctoral project by Marco Caccianiga, now professor of ecology at the University of Milan, focuses on white spruce expansion along the Hudson Bay coast over the last 400 years. Ann-Catherine Laliberté's master's work examined primary succession along the Hudson Bay coast. That coast has been emerging at the rate of 1.2 m per century; Ann-Catherine's research revealed a 400-year long formation period for the primary forest, which consists essentially of white spruce (lichen woodland). Trees in the maritime forest are generally no more than 50 years old. We are also interested in white spruce ecology on the high plateaus of Quebec-Labrador and in the Torngat-Kaumajet-Kiglapait mountain ranges along the Labrador coast. Our most recent data reveal the surprising fact that white spruce is still undergoing post-glacial migration in this region: the rugged terrain around the immense Labrador fiords has slowed the species' northward progression. White spruce is expanding in the alpine tundra of Napaktok Bay, site of Labrador's most northerly forest, while on the high interior plateaus the tree-line has retreated about 15 metres since the 19th century.

Peatlands occupy about 15% of the boreal forest, the same proportion they occupy over the entire biome in North America and Eurasia. The Northern Chair program is studying these through several projects financed by NSERC, the Ouranos Consortium, and Hydro-Québec. Two doctoral students are working exclusively on structured minerotrophic peatlands, studying the ecology of the aquatic component – pools of varying size and shape – in the context of climate change. Yann Arlen-Pouliot is looking at the origin and long-term dynamics of these pools, starting from the hypothesis that they form in a linear pattern as part of the natural cycle of microtopographic development, but that their number and size are linked closely to climatic changes, especially increased precipitation since the 19th century. Fine stratigraphic analysis of peat deposits and dendroecological analysis of living trees and subfossils are used to test this hypothesis. Maria Dissanka (co-supervised by Monique Bernier of the Institut national de la recherche scientifique, secteur Eau, Terre & Environnement [INRS-ETE]) is using Quickbird satellite images to evaluate quantitative changes over the past 50 years in the aquatic component of patterned fens. The increase in area occupied by pools is driven by aqualysis, a neologism that refers to the process of fen vegetation cover destruction by submersion from an exposed water table. Peatland aqualysis is particularly widespread in the fens of the James Bay region. Our study on the aqualysis of minerotrophic peatlands is an original contribution of the Northern Chair; the conclusions reached will be useful in the study of similar peatlands throughout North America and Eurasia in the global context of climate changes and their links to precipitation regimes.

We are studying several climatic aspects of ombotrophic peatlands, which are at their northern limit in the James Bay region. These *Sphagnum* bogs contain eastern Canada's most northerly permafrost islets, which Simon Thibault is studying for his master's research. We have shown that the permafrost in these wetlands has deteriorated considerably, apparently because of 20th-century climatic warming – particularly in the last 15 years when the average annual temperature has risen at least 2°C and precipitation has been above the 30-year average. Detailed measurements of permafrost thickness taken in mid-October 2004 and 2005 indicate the presence of marginal permafrost no more than 50 cm thick. Mapping permafrost and permafrost evidence (thermokarst depressions) shows that the permafrost limit has retreated 130 km over recent decades in the James Bay area. Added to this are the recurrent effects of fire on bog vegetation in this region, which is one of the most fire-prone in eastern Canada. A stratigraphic study of fires recorded in peat deposits in bogs by master's student Gabriel Magnan (co-supervised by Martin Lavioe, professor of geography at Laval and a Northern Chair collaborator) is working on demonstrating the synergistic effect on fire propagation of vegetation type and climate.

Subarctic permafrost dynamics are also being studied, especially in the Boniface region where the Chair team has a permanent research camp providing proper logistics for student work. Several permafrost projects are under way in this area. Master's student Sheila Vallée studied the evolution of riparian permafrost (which is scattered along the riverbed and banks of the Boniface) over the past 50 years, and recorded a 23% reduction in the area occupied by mineral palsas (mounds of perennially frozen peat and mineral soil). The area has the highest palsas in the circumboreal world – over seven metres high and several hundred square metres in area. They are being studied in detail by master's student Sébastien Cyr who has determined that they are over 1000 years old and are slowly but progressively breaking down because of 20th-century climate warming.

Several structuring research projects will be launched this year dealing with boreal forest stability in the face of natural disturbances (climate and fire) and man-made disturbances (logging), in light of the march northward of the forest industry. The Northern Chair is interested in collaborating with Nunavik residents to evaluate the impact of forestry practices on tree regeneration. Research on northern ecosystem biodiversity in relation to disturbance type and regime is planned for this year; by summer we will establish a long-term ecological monitoring network on the evolution of alpine tundra on selected high summits ranging from the southern limit of the closed-crown forest up to the edge of the forest tundra. Detailed analysis of floral diversity (vascular and cryptogram) at the alpine sites, as well as of vegetation and soils, will aim to identify ecological changes directly relevant to the anticipated impact of climate changes in the boreal forest. Particular attention will be given to the dynamics of alpine tundra colonization by boreal species – trees and others – and to the correlative reaction of arctic-alpine species.

Although the Northern Chair on the ecology of forest disturbances is a recent creation it has already proved its worth. It has developed many high quality research projects and spawned numerous successful master's and doctoral theses that would not have been completed otherwise, given the high cost of northern research.

Without NSERC support it would have been impossible to undertake so many worthwhile projects, especially given that logistical support from Polar Continental Shelf – despite its mandate to support northern research – is not currently available in Nunavik. We are hopeful that one day that organization's management will abandon its narrow perspective and embrace a more equitable distribution of Canada's northern logistical resources. The absence of support from Polar Continental Shelf places considerable strain on research logistics capacity in Nunavik, hampering research efforts in areas of national importance.

Thankfully, some organizations with clearer and more comprehensive vision, such as our current partners, are supporting the many activities of the Chair in our two main areas of research. We expect that our involvement in ecosystem restoration, and in the analysis of northern ecosystem dynamics for the benefit of science and of northern residents, will continue to increase.

Serge Payette is Professor in the Department of Biology and Member of the Centre d'études nordiques, Université Laval. He holds the Natural Sciences and Engineering Research Council (NSERC) Northern Research Chair in the ecology of forest disturbances.

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ADAPTING TO CHANGE IN CANADA'S NORTH: VOICES FROM FORT RESOLUTION, NWT

Sonia Wesche

Since the summer of 2004 I have been involved in environmental change research with the community of Fort Resolution, NWT. Building on a community research partnership with physical science colleagues undertaking paleohydrology studies, my work examines the capacity of local people to adapt to environmental and socio-cultural change.

A particularly productive facet of my research involves understanding how people interpret and experience change. A recurring theme emerges: local people seek to balance traditional and western culture (in the way they relate to the world, and in terms of their own identities) to adapt to their changing environmental context.

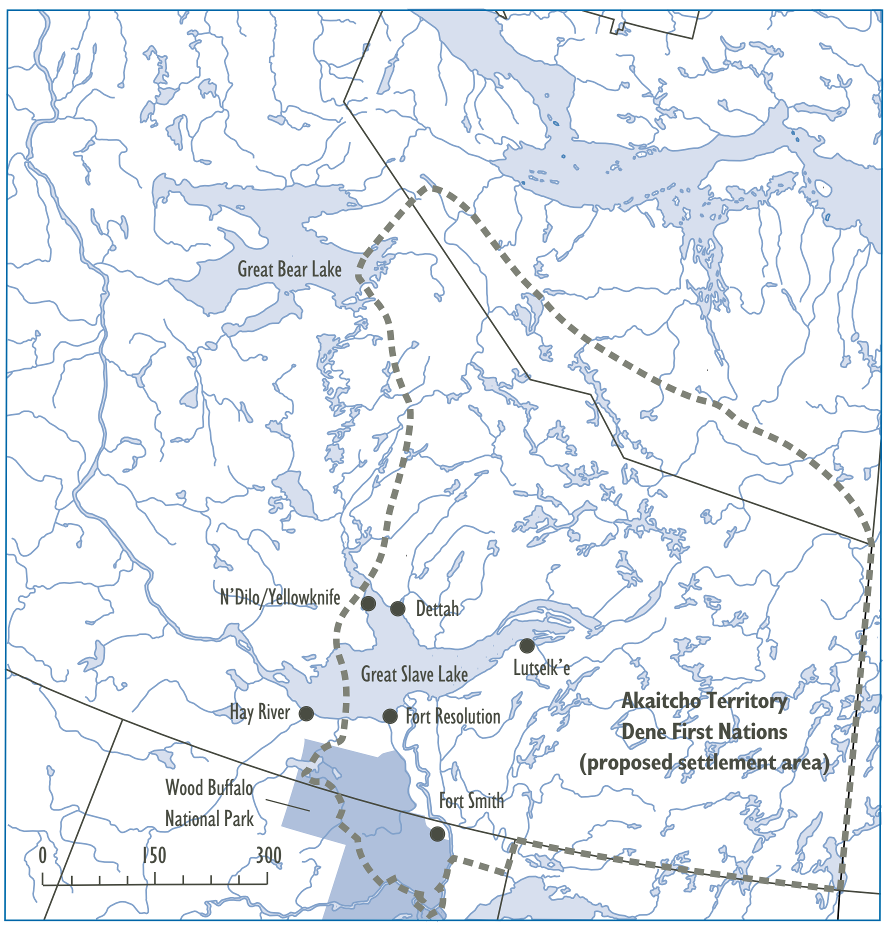
Effective northern research and development projects require cross-cultural collaboration with aboriginal partners (Wolfe *et al.,* 2007). Understanding the historical socio-cultural context within which individuals and communities function is essential. Yet, in the academic literature on adaptation to environmental change, the voices of the people who live these changes are often sidelined. I attempt here to bring some northern voices to the fore, in the hopes that sharing these perspectives will help generate understanding, within the research community and among others involved in the North, about the many factors that influence how aboriginal northerners respond to a rapidly changing environment. The narratives and ideas presented here are based on field experience and interviews conducted in 2005 and 2006 in the Dene-Métis community of Fort Resolution, NWT.*

* All individuals mentioned here consented to public release of their statements and to being identified by name.

STUDY SITE: FORT RESOLUTION, NWT

Fort Resolution is the oldest documented settlement in the Northwest Territories, having originated in the early 1800s as a central fur trading post along the northern river travel route. The small community of about 550 mostly Dene and Métis lies within the Akaitcho Traditional Territory (currently under Treaty negotiations), and is now accessible by road from Hay River.

People in Fort Resolution have endured a long history of change caused by outside influences. These include the early influx of fur traders and southern trappers, devastating new diseases like influenza and



Location of the research study site. The community of Fort Resolution lies on the south shore of Great Slave Lake, N.W.T. within Akaitcho Traditional Territory.

Fred Mandeville Jr. tests the ice before crossing by snowmobile in early spring, 2006. Knowledge of water currents and ice quality is essential for safe travel on Great Slave Lake. Photo: S. Wesche.

tuberculosis, a mission school and hospital that operated during the early to mid-20th century, government policies on aboriginal assimilation, settlement, and heritage, the introduction of new land use and livelihood technologies, increased access to the wage economy and western ideologies; and more recently, rapidly changing environmental conditions.

Fort Resolution's residents have long depended on the ecological resources of the nearby Slave River Delta for food and fur. Despite a recent marked reduction in traditional land use, they continue to hunt, fish, and trap for both recreation and income. The integrity of the surrounding ecosystem is also essential for newer economic endeavours like tourism, and to support local attempts to revive cultural traditions and knowledge tied to the land.

RESEARCH PROCESS

My collaborative research project aims to understand how the natural ecosystem functions and responds to various environmental stressors, and to enhance the stewardship of natural resources and the capacity of local residents to respond to change. Since June 2004 I have spent a total of ten months in Fort Resolution, visiting repeatedly during different seasons, living with a local family, and being taken into the bush to learn about the traditional territory and land use practices. As a result I have been able to gain invaluable experience and understanding of community dynamics. The fact that most people in Fort Resolution speak English enabled me to engage in informal discussions, participate in community meetings, and read planning and policy documents, environmental meeting minutes, scientific and traditional knowledge reports available there.

Working with local assistants, I conducted 33 semi-structured interviews with elders and land users, concentrating on their knowledge of environmental changes (*e.g.,* weather, water, ice, animals, plants), the effects on people over time, and how people have adapted in the past. Another nine interviews with individuals involved in resource management policy and practice at local, territorial and national levels focused on the capacity of existing institutions to collaborate effectively and support local adaptation strategies. For both sets of interviews I followed a general framework of questions, but left room for interviewees to elaborate, especially in their own areas of interest and expertise. This made the interview more satisfying for the interviewees and expanded the breadth and practical relevance of my research.

I also held five different focus groups where we discussed possible future scenarios of change, involving climate and resource development. These sessions aimed to stimulate discussion around the areas where residents feel vulnerable to change, and what they could do individually or as a community in order to cope. With the help of local research assistants, I also implemented a survey of 104 heads of household. We used a structured questionnaire to understand key features of social relationships and networks and how these relate to people's ability to adapt to change.

I was fortunate to participate in some 15 guided trips on the land where I engaged in hunting, trapping, and fishing activities during different seasons. Learning about the practicalities of life on the land and seeing and discussing landscape features first hand is essential to understand northern life, how locals assign value to environmental features, and the interplay between social and ecological elements within the broader system.

This article seeks to provide insight about how people in Fort Resolution, individually and collectively, are dealing with change. Drawing directly on the knowledge and views of participants in my research project, it provides a cross-section of voices of people coping with change on emotional, mental, physical and spiritual levels. It communicates their views only, and is not meant to represent those of the Dene or Métis people as a whole, nor of the entire community of Fort Resolution.

CHANGING ENVIRONMENTAL CONDITIONS

Environmental change is a common topic of discussion in Fort Resolution. However, while most residents recognize that it is occurring and affecting people, they believe they can do little to influence it or mitigate its effects.

Changes in the climatic regime are causing concern as they become more frequent and more pronounced. Locals note that winter temperatures used to drop consistently to −50°C, whereas winters now tend to be warmer and shorter, generally with less snow. Furthermore, conditions are noticeably more variable, with temperatures fluctuating from one day to the next. Residents have experienced several cold springs recently, and an extremely varied snow pack during the last few winters. Often such variability limits access to the land. For example, a heavy snowfall in early fall 2005 slowed freeze-up and caused a layer of melt water to develop under the snow, making it unsafe to travel on the ice until temperatures dropped.

Despite these noted shifts the general consensus is that climate change is only part of the problem. Locals have noticed other environmental variations, which they attribute largely to industrial development in the provinces – including hydrological changes influenced by the W.A.C. Bennett Dam on the Peace River in northern B.C., and contamination from oilsands and other developments in Alberta:

> *In 1967 they built the Bennett Dam and held water back for three years to fill the reservoir. In the [Slave] delta, the prairies and sloughs used to be full of [musk] rats, so they kept the willows down. They chewed on the shoots. [...] The rat population will go down ... and after a flood it will rebound. [...] Where they held the water back, the land dried out and willows started to grow. There weren't enough rats to keep them down, so ... the slough will never go back to being good rat habitat.* (Angus Beaulieu, 2005)
>
> *The whole country, the whole land, the whole environment is changing because of low water level. I can see the changes in the trees, in the ways plants are growing. Some of the food is drying out, some traditional pathways are overgrown because of lack of water. Back in the old days, in the winter they had a lot of caribou that was migrating through the area ... then it dwindled to the point where there are none today [...]. Not only the population is down ... the forest fires have depleted all the lichen that the caribou had depended on to winter in this area.* (Gabe Yelle, 2005)

Other changes in animal health have also been noted; of particular concern is an increase in fish deformities. Populations of several primary food and fur species have decreased (*e.g.,* beaver and muskrat). Other locally-identified impacts include increased difficulty in planning travel on the land, travel safety concerns, limited access to land-based activities, and decreased pelt values (fur does not reach prime in warmer conditions).

Most affected by change are those who use the land or its resources directly – harvesters, elders and the many others who rely on the food and furs they obtain. In recent years, people have tended to make individual adaptations, including: increased use of communications technology (*e.g.,* satellite phones), employing different equipment (*e.g.,* ATVs) for land access, diversifying economic activities, and altering land use patterns. However, as they now face unprecedented extremes and rates of environmental change, northerners will have to prepare more systematically for future conditions.

CHANGING SOCIAL AND ECONOMIC SYSTEMS

Despite recent media focus, climate change is only the most recent phenomenon to cause major upheaval to northern peoples. Socio-cultural conditions have also changed rapidly in recent decades, and the resulting cumulative effects make it more difficult for people to adapt.

> *The community is new to us because we're nomadic people. We're used to hunting and gathering and travelling and being part of the land, but then the people start going to the communities, and the government kind of tried to assimilate us, and brought us to boarding schools and that took our identity away. [...] Before ... the people that gave [the] most of themselves had the highest stature in the group. [...] But, when they moved to the communities and adopted the community system, it wasn't how much they gave that gave them status, but how much we accumulated that gave status. So it went against our value system and eroded our way of looking at working together.* (Maurice Boucher, 2005)

Several interviewees note that their identities as aboriginal people are inherently tied to the land and to the traditional way of doing things. In the one generation it took to move from paddling a canoe to using speedboats, televisions, telephones, microwaves, and planes, people have become increasingly disconnected from the land, losing their focus on what is out there and who they are. People are searching for their own identities. A connection with the land and one's ancestors provides a grounding that has in large part been lost over recent decades.

> *If you take the spiritual part away from the human being, then everything else goes with it.* (Kevin Boucher, 2005)

Over the past four decades technology and shifting livelihood priorities have drastically altered land use patterns.

> *Now land use is almost spontaneous. We can go out and do things within a certain weather frame. [...] You wake up and it's this beautiful day and you're going to go all the way across to Simpson Islands and you can be back before that evening storm comes in. That's so untraditional. [...] Now that we can do things so much quicker, it pulls you so much away from some of the more traditional ways of doing things. We're no longer in these 2.5 kickers, we're in 9 horse kickers, and you don't even feel the waves because you're planing on top of the waves. Whereas in the 2.5 you felt every wave, [and] you couldn't go by a berry patch; even if you didn't see it you couldn't go by it because you'd smell it.* (Bernadette Unka, 2005)

> *Life is too instant now.* (Henry King, 2005)

One of the perceived consequences of shifting away from the land and its values is an increased focus on individual status and a reduced spirit of cooperation among community members. The resulting strains on social bonds make communities less able to respond to the many pressures they are facing.

> *I think in the past ... people worked really close together in family units for the purpose of surviving, etcetera. And, now ... when people go into private business, it's more for themselves. [...] Collectively, as a First Nation, it's becoming more difficult to get the whole community to buy into concepts and work collectively on a vision, so to speak, to move forward. It's getting more difficult because of so much outside influences.* (Don Balsillie, 2006)

BALANCING TRADITIONAL AND WESTERN WAYS OF BEING

Occurring simultaneously with changing livelihoods and land use is the loss of traditional knowledge, which limits possibilities for the younger and future generations to incorporate traditional ways into their lives. Parents and elders worry that while young people may be learning some of the skills needed on the land or water like driving a boat, using a shotgun, or cleaning fish, they lack the value system attached to traditional ways of living. The result is a commodification of attitudes towards the land; younger generations are more willing to allocate sections of their traditional territory for resource development. Any potential economic benefits are however severely mitigated by inadequate individual and community preparation. People lack awareness, experience, and education, leaving them vulnerable to exclusion from decision-making, inequitable compensation agreements, and other forms of exploitation by outsiders.

Some interviewees are aware of the need to build local capacity. When asked their opinions on the best way for aboriginal people and communities to move forward, many identified the need to combine traditional and western knowledge and ways of being to create a healthy and prosperous society.

> *I think there's a need to ... find a balance. That's what it is. It's to find a comfortable balance between those two [traditional and western] worlds. And, if you can do that, then basically those people will be empowered because they'll have the traditional knowledge and feel comfortable in that area, and have also in the new world the educational tools to help them. Then you've got the best of both worlds, so to speak.* (Don Balsillie, 2006)

Achieving this balance presents many challenges. In addition to the need for spiritual healing and access to financial resources, the lack of human capacity in northern aboriginal communities presents a major obstacle to effective engagement with the modern world. Interviewees said many times that better and more comprehensive education is essential. Improving local education means confronting such issues as lack of support from parents (who tend to have little education themselves), integrating traditional and western teachings in the classroom, raising the education levels of decision-makers, and providing incentives for community members who have gained professional skills elsewhere to return to their communities of origin.

Included in traditional teachings is the question of aboriginal identity. A number of interviewees mentioned this, and all linked their sense of self to their cultural roots and relationship to the land. Although many community members do not themselves go out on the land, all rely at least in part on the products generated by those who do. Furthermore, there is general consensus that maintaining the health and integrity of their traditional territory is fundamental to maintaining a healthy community.

> *You have to be connected to the land; that's where you get your identity from. That's where you realize what you are. You become humble when you know that the water could take your life, like that, in one instant. You always have respect for the land because it's unforgiving. If you fall through the ice in the wintertime the chances of surviving are pretty slim if you're alone.* (Maurice Boucher, 2005)

"The land speaks to you", says Kevin Boucher (2005). He sees Mother Earth as the mother of all people, and the respect he shows in return for her nurturing and abundance is deeply rooted in his cultural beliefs. Traditional ceremonies such as putting tobacco down into the water when travelling by boat, and following specific protocols of thanksgiving when harvesting animals such as moose, bear or bison, keep people connected to the land.

Although traditional knowledge has been declining throughout northern aboriginal societies for at least half a century, a recent trend in cultural revival seems to be emerging. Several individuals echoed Don Balsillie's comment:

> *I think that a lot of people are going back to try to understand their roots, their language, and who they are. I think it's important for them to do that.* (Don Balsillie, 2006)

One of the expected outcomes of this revival is increased community cohesion, which can improve the capacity of local people to work together to adapt to change.

> *The problem is that people don't know their own history. They don't realize we all come from the same place and are all one people. Learning joint history may help to bring people together.* (Lena McKay, 2006)

The author waiting for geese at a blind on Great Slave Lake in May, 2006. Learning about traditional land use and dynamics of the ecological system is best done by travelling on the land and participating in activities with knowledgeable locals. Photo: F. Mandeville Jr.

LOOKING FORWARD: BUILDING CAPACITY FOR THE FUTURE

Most local people in Fort Resolution view climate change as a threat to their way of life, yet it remains secondary to more immediate problems, as in most communities. As mentioned earlier, people are well aware that change is occurring, but they do not fully recognize the consequences, nor do they believe that their own actions can help mitigate the impacts. For those who expressed themselves on this issue, reconnecting with cultural roots predominates as the primary mechanism for dealing with a changing landscape, and for improving cohesiveness and wellbeing in the community.

> *Now I think what people need to do is to take back their responsibility, and their responsibility is to take care of Mother Earth. We were given the responsibility of stewardship, and that stewardship meant that we have to take care of the land and the environment, and every organism had to be in balance. And*

somehow man is lately unbalanced. We are not monitoring regularly – revisiting, reviewing the detrimental impacts that we are having. (Bernadette Unka, 2005)

Potential exists for building on community identity and history at the grassroots level in order to instill collective stewardship values and encourage people to work together. Despite inter-familial and inter-cultural divisions created in large part by historical social upheaval, people do feel connected and provide support to one another in tragedy or crisis.

When someone is in need, when someone is hurting, whether there's a death or something in the community, I can't tell you how much love you feel. [...] We come together like one huge family, and all those differences all fall to the wayside; none of those are important. (Bernadette Unka, 2005)

Beyond the necessary rebuilding of social networks and cultural ties, locals also see the need for capacity-building in such areas as access to financial and human resources, expertise in governance and resource management, and sustainable employment opportunities. The local Treaty Negotiator Paul Boucher (2006) maintains that local leaders must be dedicated and well-meaning for the community to move forward. Preparing the leaders of tomorrow requires incorporating traditional values within the education system, and the re-empowerment of family units. The focus on education and training is uppermost in many local leaders' minds.

You see a lot of kids that are finishing high school, which is a good thing. Hopefully with our [ongoing Treaty] negotiations we get more help from the government, and people in place and jobs in place and ... we could govern ourselves [...]. Maybe not my generation, maybe my kids' generation or my grandkids' generation – we might be able to do that. (Maurice Boucher, 2005)

In recognition of the importance of both education and locally-relevant research, community leaders have also mentioned their wish to continue developing a long-term partnership with southern researchers. In the case of Wilfrid Laurier University for example, the research relationship with Fort Resolution goes back to the 1970s. While such partnerships can provide a framework for addressing local concerns and building capacity through local involvement, leaders also mentioned benefits in engaging researchers as mentors for young students.

Residents recognize that local capacity-building must be supported by government policy and practice to be effective. Yet, to date, little has been done to develop policies to mitigate and adapt to change. The lack of congruency between current northern research and environmental decision-making prompts organization of events such as the recent N.W.T. Climate Change Leadership Summit, to "help leaders from across the N.W.T. learn more about climate change, as well as adaptive measures that N.W.T. communities can take in the face of climate change" (*Ecology North,* 2007). Summit organizer Doug Ritchie notes that it is essential for government bodies at all levels to engage actively in climate change adaptation planning and implementation, as they hold the necessary sway and staying power to carry out a long-term program.

CONCLUSIONS

Northern communities are facing multiple pressures which will continue to impact natural and human systems well into the future. Coping with change requires targeted capacity-building at the local level, with sustained support from higher levels of government, to improve the adaptability and resilience of these systems.

The people of the North hold a wealth of knowledge about their environment and have much to say about how these changing conditions should be approached. To support them effectively in building their adaptive capacity, it is imperative to take into account both the challenges and opportunities – whether social, economic, political, or environmental – facing northern communities. An essential ingredient in this process involves listening to the voices of northerners and their personal experiences with change.

Sonia Wesche is a Ph.D. candidate in geography at Wilfrid Laurier University. She was awarded the 2006 Polar Commission Scholarship.

Interviewees

The following are some of the individuals who discussed with me their perspectives on their changing northern environment and its impact on their lives and community. Their comments formed the basis of this article.

Don Balsillie (land user, local government), April 3, 2006;
Angus Beaulieu (elder), July 5, 2005;
Kevin Boucher (land user), July 8, 2005;
Maurice Boucher (land user), August 31, 2005;
Paul Boucher (land user, local government), April 3, 2006;
Kenneth Delorme (land user), June 26, 2005;
Henry King (elder), September 1, 2005;
Lena McKay (land user), May 3, 2006;
Ronald McKay (land user), July 7, 2005;
Bernadette Unka (elder, local government), Aug 23, 2005;
Gabe Yelle (elder), June 20, 2005;
Doug Ritchie (Ecology North, Yellowknife), April 27, 2006.

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Wolfe, B., D. Armitage, S. Wesche, B. Brock, M. Sokal, K. Clogg-Wright, C. Mongeon, M. Adam, R. Hall and T. Edwards. "From Isotopes to TK Interviews: Towards Interdisciplinary Research in Fort Resolution and the Slave River Delta, NWT." *Arctic,* vol. 60, no. 1, March 2007.

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KLUANE NATIONAL PARK MANAGEMENT BOARD COORDINATES A NATIONAL CONFERENCE: "LEARNING FROM COOPERATIVE MANAGEMENT"

Shawn Allen

Aboriginal groups face a variety of challenges in their role to implement cooperative management agreements that pertain to Canadian National Parks. This is widely accepted nationally and documented in studies worldwide. The 1995 Circumpolar Aboriginal People and Cooperative Management Workshop clearly recognized that cooperative management does work. It was also recognized that improved communication, trust, respect, common goals and a way of integrating land based knowledge with scientific studies would support more effective practices of cooperative management.

In 1997 a worldwide report by the International Union for the Conservation of Nature Inter-commission Task Force on Indigenous Peoples concluded that in conservation management, there is still the tendency to ignore or give low priority to the rights of indigenous peoples from national parks and other protected areas.

The 2001 report "Northern Parks – A New Way" presented by the Subcommittee on Aboriginal Economic Development in Relation to Northern National Parks, Standing Senate Committee on Aboriginal Peoples makes similar conclusions. They acknowledge that aboriginal people recognize the land set aside as National Parks in their traditional territories as special and sacred places.

Caroline Hayes, Chair of the Kluane National Park Management Board notes, "The timing for the conference is appropriate. Nationally there has been a movement within Parks Canada to develop cooperative management agreements. This project will provide a first time opportunity for aboriginal boards and Parks Canada staff to work together on a national level to collectively explore cooperative management issues."

Parks Canada relations with aboriginal peoples have been solidified through constitutionally protected comprehensive land claim agreements and modern day treaties, as well as through national park establishment agreements, memorandums of understanding and cost sharing arrangements. The variety of agreements poses

Entrance to Auriol Trail, Kluane National Park. Photo: Shawn Allen.

Kathleen Lake, Kluane National Park. Photo: Shawn Allen.

challenges and creates successes, of which not all are commonly aware. In Canada there are 28 National Parks, National Park Reserves and National Historic Sites that have formal consultation cooperative management agreements with aboriginal groups. Of these, approximately half were established through the provisions of comprehensive land claim settlement agreements, with the other half through requirements of park establishment agreements, Memoranda of Understanding with aboriginal communities, or through local stakeholders and aboriginal community representatives invited to participate. One was established through a treaty land entitlement (specific claim) agreement.

Parks Canada recognizes the social, cultural and economic importance of linking aboriginal people to Parks policies through cooperative management initiatives. Aboriginal board representatives working together with Parks Canada staff will strengthen relationships sensitive to aboriginal perspectives. The goal of the conference "Learning from Cooperative Management" is to establish true and equitable partnerships that combine existing technologies with the extensive traditional knowledge of aboriginal people to preserve the the land's ecological integrity and respect the aspirations of aboriginal people. The outcome will be a printed text presented as a tool of best practices for the management of Park lands and resources.

The conference will be held in Haines Junction, Yukon on April 24–26, 2007. A conference website at www.kpmb.org has been set up for delegates to register. Registration priority will be for aboriginal boards and committees that work with National Parks and Parks Canada employees. The conference may be open to academics and other interested parties based on availability of seats.

The Kluane National Park Management Board is initiating this project with their co-hosts, Champagne & Aishihik First Nations, Kluane First Nation, and the Kluane National Park & Reserve. The Board gratefully acknowledges our sponsors, the Walter & Duncan Gordon Foundation, Indian & Northern Affairs Canada, Parks Canada, Government of Yukon, and appreciates assistance from the Yukon Convention Bureau and the Village of Haines Junction.

Shawn Allen is with the Secretariat for the Kluane National Park Management Board.

BOOK REVIEW

Kenn Harper

Apostle to the Inuit: The Journals and Ethnographic Notes of Edmund James Peck, The Baffin Years, 1894–1905, edited by Frédéric Laugrand, Jarich Oosten and François Trudel. Toronto: University of Toronto Press, 2006. ISBN 0-8020-9042-7.

For too long the Reverend Edmund James Peck has been an enigmatic figure in Arctic mission history and in the history of Baffin Island. Known as the "Apostle to the Inuit" the Anglican missionary brought formal Christianity to the Inuit of Arctic Quebec and then to the Baffin region – yet the details of his life and work and his contribution to our knowledge of the historical Inuit went undocumented. The only book-length biography, *The Life and Work of E.J. Peck among the Eskimos,* by Arthur Lewis, was published over a century ago, before his work at Blacklead Island had ended. Like many missionary biographies it was heavy on hallelujahs and light on substance.

Now three respected academics known for their studies of Inuit history and beliefs have collaborated on a work of almost 500 pages dealing exclusively with Peck's Baffin years, the four two-year terms he spent at Blacklead Island (interspersed with one-year furloughs to England) between 1894 and 1905.

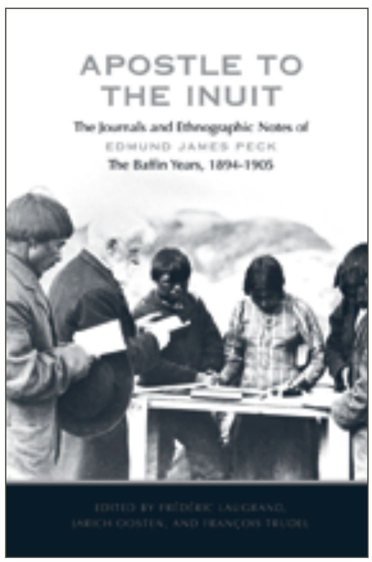
The facts of Peck's career can be recounted easily enough. He was born in England in 1850 but raised from the age of seven in Ireland. Orphaned at thirteen, he spent eight years in the British Navy before answering a plea that Rev. John Horden, Bishop of Moosonee, had made to the Church Missionary Society for a man who could devote his time almost exclusively to the Inuit on the Quebec Hudson Bay coast. Between 1876 and 1892, Peck served two terms as missionary at Little Whale River and Fort George, resuming the interrupted work begun in the 1850s by Rev. E.A. Watkins. In 1894, leaving his wife and daughter behind in England, Peck established a new mission to the Inuit at the whaling station of Blacklead Island in Cumberland Sound, the main centre of commercial activity north of Hudson Strait. After leaving Blacklead Island in 1905, Peck moved with his family to Ottawa where he became Superintendent of Arctic Missions, travelling north occasionally on supply vessels in the summer. He died in Ottawa in 1924.

Apostle to the Inuit begins with a lengthy introduction describing the founding of the mission on Blacklead Island and the way in which Christianity was introduced to the Inuit. This background, augmented by a very helpful chronology of the significant events in the eleven years under study, puts in context the main body of the work which follows in two major sections.

The authors devote over 200 pages to Peck's journals of his eleven-year residence in Cumberland Sound. These are presented primarily as extracts, with very little commentary. This works – the extracts speak for themselves.

But it is "Part Two: The Ethnographic Documents," which is the more interesting. Missionaries are not usually ethnographers. Most feel their task is to eradicate, rather than record, the "heathen" beliefs of pre-Christian times. Peck might very well have fallen into this camp too – there is certainly nothing in Peck's earlier writings of his time on the Hudson Bay coast, or even in his notes from his first few years at Blacklead Island, that indicates any interest in these subjects – had it not been for an invitation from the pioneer anthropologist Franz Boas. Boas, who had spent 1883–84 in Cumberland Sound, asked Peck to document for him the Inuit belief system, including shamanic rituals and legends. Already unconventional in many of his attitudes to how missionary activity should be conducted, the request struck a chord in Peck and he took up the challenge with his customary energy. The resulting contribution to Inuit ethnography has sat largely untouched and unrecognized for over a century in the General Synod Archives of the Anglican Church of Canada.

It is this remarkable collection of information that the authors present. An introductory chapter, "The Ethnography of Peck", is followed by four chapters of Peck's own documentation of Inuit customs. Chapter titles give the flavour of the work: "The Eskimos, Their Beliefs, Characteristics, and Needs", "Describing 'Heathen Customs'", "The Tuurngait" [helping spirits], and "List of Spirits by the Missionary E.J. Peck". Of especial interest are three chapters of stories recorded verbatim from Inuit themselves: Eve Nooeyout, Oosotapik, and Qoojessie.



The authors might have provided more background on the history of Blacklead Island prior to Peck's arrival. Discovered – and I mean in the classical sense in which the first white man to enter an area inhabited by non-whites is heralded as a discoverer – by John Davis in 1585 and not rediscovered until 1840 by William Penny with the help of the Inuk Eenoolooapik, parts of Cumberland Sound had been continuously occupied by whalers for almost half a century before Peck's arrival. Indeed whaling was in serious decline well before 1894. While Boas's own major account of Inuit life and beliefs scarcely mentions the white presence, giving the reader an inaccurate picture of Inuit living a traditional life unsullied by foreign influences, Peck does not gloss over the presence of the whalers and the vices and diseases they had brought to the people he had come to save.

A few quibbles with fact and interpretation: William Penny reached Cumberland Sound in 1840, not 1839 (page 12). Mr. Noble (Crawford Noble) was not the agent at the whaling station at Kikkerton in the 1880s; rather, he was the owner, resident in Scotland, who employed the agents who lived on the island (page 14). A photo caption on page 25 purports to identify the first three Inuit converts on Blacklead Island, but, if conversion is marked by baptism, it is in error; the first Inuk to be baptised on the island was Annie Atungaujaq, who died in June 1901, little more than a month after her baptism on May 7 of that year.

The spellings of Inuit names and Inuktitut place-names in the text generally follow Peck's own renditions. But in the authors' own descriptive text, where they introduce names not used by Peck, they generally attempt to use the modern official Inuit orthography. In this they are deficient. In particular, Peck's own Inuktitut name was Uqammak (the one who speaks well), not Uqammaq (page 10 and elsewhere). (A small "*mea culpa*" is required here. In citing my short unpublished biography of Peck that is on file at the General Synod Archives, they accurately quote my own early misspelling of Peck's Inuktitut name as "Uqarmat." That shouldn't, however, give them the right to mis-spell my first name as "Ken" on page 3!) Joseph Parker was called Luuktakuluk (the small doctor), not Luktaakuluk (page 16), and Greenshield was Ilataaqauk (the new member of the family), not Ilataaqqau (page 16). Blacklead Island itself, on the map that accompanies the introduction, should be Uummannarjuaq, not Uumanarjuaq.

But these are small points in a major work. The authors have accomplished very well their objective of placing Edmund James Peck firmly among the roster of those who have made major contributions to documenting the pre-Christian beliefs of the Inuit. The Apostle to the Inuit takes his place as an ethnographer who performed the unusual task – one might call it an almost schizophrenic task – of eliciting and documenting the very belief system he was so firmly dedicated to extinguishing.

Kenn Harper is a historian and linguist living in Iqaluit, Nunavut.

NEW BOOKS

Names & Nunavut: Culture and Identity in the Inuit Homeland, by Valerie Alia. Berghahn Books, 2007. ISBN 978-1-84545-165-3.

A Complete Guide to Arctic Wildlife, by Richard Sale with photographs by Per Michelsen and Richard Sale. Firefly Books Ltd., 2006. ISBN: 1-55407-178-X.

HORIZON

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ess.nrcan.gc.ca/ipygeonorth/index_e.php

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October 19–21, 2007
University of Saskatchewan, Saskatoon, Saskatchewan
www.dbakerproductions.com/acuns/index.htm

CORRECTION

In the Fall-Winter 2006 edition of *Meridian* two organizations were incorrectly identified: NSERC is the Natural Sciences and Engineering Research Council of Canada, and IASC is the International Arctic Science Committee.

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Canadian Polar Commission
Suite 1710, Constitution Square
360 Albert Street
Ottawa, Ontario
K1R 7X7

Tel.: (613) 943-8605
Toll-free: 1-888-765-2701
Fax: (613) 943-8607
E-mail: mail@polarcom.gc.ca
www.polarcom.gc.ca