Science for a Changing North II

2011 Sudbury Restoration Workshop

Feb. 23-24, Laurentian University

Cooperative Freshwater Ecology Unit
Unité Conjointe D'écologie D'eau Douce

Science for a Changing North II Schedule at a Glance

Sudbury Restoration Workshop Feb. 23-24, 2011

Date	Time	Program	Location
Tuesday, Feb. 22nd	7:00pm	Living with Lakes Social (7:00pm Coffee and Dessert, 7:30pm IMAX, 8:15pm Skating)	Lakehouse Restaurant, Science North
Wednesday, Feb. 23rd	8:00-9:00am	Registration, Poster set-up, Coffee	Fraser Lobby
	9:00-9:15am	Dominic Giroux, LU President, Welcome	Lower Fraser
	9:15-10:00am	David Pearson (LU), "Science in a Changing Far North" - Recommendations of the Far North Science Advisory Panel	Lower Fraser
	10:00-10:30am	Coffee and Poster Session	Fraser Lobby
	10:30-11:00am	Bill Keller (LU), Aquatic Resources in Northern Ontario: Science Needs, Challenges and Opportunities	Lower Fraser
	11:00-11:30am	Andy Fyon (OGS/MNDMF), Ethical Engagement and Science – Paradox or Synergy, Ontario's Far North	Lower Fraser
	11:30-12:00pm	Dianne Corbett (MNR), The Far North Land Use Planning Initiative: Making Wise Decisions About Conservation and Resource Development Opportunities	Lower Fraser
	12:00-1:00pm	Lunch and Poster Session	Alumni Hall
	1:00-1:30pm	Christine Kaszycki (MNDMF), Ring of Fire: Opportunities for Northern Ontario	Lower Fraser
	1:30-2:00pm	Glenn Nolan (Noront Resources), Approach to Aboriginal Engagement	Lower Fraser
	2:00-2:30pm	Doug Morrison (CEMI), New Technologies and Approaches for Environmental Sustainability	Lower Fraser
	2:30-3:00pm	Coffee and Poster Session	Fraser Lobby
	3:00-3:30pm	Tom Johnston (MNR/CFEU), Mercury Contamination of Northern Fishes	Lower Fraser
	3:30-3:50pm	Nadia Mykytczuk (McGill), Microbial Communities in the Canadian High Arctic: Early Insights into a Changing Climate	Lower Fraser
	3:50-4:10pm	Dean Millar (LU/ MIRARCO), Permafrost Melt Experiment – Innovative Engineering Designs	Lower Fraser
	4:10-4:30pm	John Gunn (LU) Day 1 Workshop Wrap Up	Lower Fraser
	4:30-5:30pm	Poster Social with Refreshments	Fraser Lobby
	5:30pm	Dinner featuring Guest Speaker Norman Yan (York),"Highlights of the Water Forum in Advance of the G8 Meeting"	Alumni Hall
Date	**Time**	**Program**	**Location**
Thursday, Feb. 24th	8:00-8:30am	Registration, Coffee	Fraser Lobby
	8:30-8:50am	Andrew Paterson (MOE), A Review of Water Quality and Phytoplankton from Lakes in the Hudson Bay Lowlands, Northern Ontario	Lower Fraser
	8:50-9:10am	Kathleen Rühland (Queens), Recent Changes in Diatoms and Other Paleoindicators from Lakes in the Hudson Bay Lowlands, Northern Ontario Over the Last ca. 100 years	Lower Fraser
	9:10-9:30am	Michelle Brazeau (Ottawa), Characterization of Lake Sediment Microbial Communities in a Warming Climate and Their Impact on the Mercury Geochemical Cycle	Lower Fraser
	9:30-9:50am	John Gunn (LU), Climate Warming Effects in Subarctic Rivers: Building on Traditional Knowledge	Lower Fraser
	9:50-10:10am	Chris Jones (MOE), Benthic-invertebrate Communities in Lakes and Streams of Ontario's Far North (Sutton Ridge and Hudson Bay Lowlands)	Lower Fraser
	10:10-10:40am	Coffee Break	Fraser Lobby
	10:40-11:00am	Derek Mueller (Carleton), Remote Sensing in the Far North:Detecting and Evaluating Environmental Change in the Coastal Cryosphere	Lower Fraser
	11:00-11:20am	Sarah Finkelstein (Toronto), Paleoclimates, paleoecology and Biogeochemistry in Ontario's Hudson Bay Lowlands	Lower Fraser
	11:20-11:40am	Brent Wolfe (Wilfrid Laurier), Isotopic Approaches for Characterizing Present and Past Hydrology of the Western Hudson Bay Lowlands	Lower Fraser
	11:40-12:00am	Shelley Arnott (Queens), The Impact of Environmental Change on Aquatic Communities in Wapusk National Park	Lower Fraser
	12:00-1:00pm	Lunch	Alumni Hall
	1:00-1:20pm	Chris Charron (MOE), Carbon Flux Monitoring in the Hudson Bay Lowlands	Lower Fraser
	1:20-1:40pm	Jeff Amos (MNR), Ontario's Broad-scale Lakes Monitoring Program: Design and Initial Results	Lower Fraser
	1:40-2:00pm	Steve McGovern (MNR), Far North Aquatic Science Projects: MNR/NESI Preliminary Investigations under the Far North Information and Knowledge Management (FN-IKM) Initiative	Lower Fraser
	2:00-2:20pm	Peter Barnett (MNDMF), Remote Predictive Mapping of Surficial Materials in the Far North of Ontario	Lower Fraser
	2:20-2:40pm	Katherine Garrah (LU), Determining Soil-Plant Reference Conditions for the Reclamation of Mine Stockpiles in the Hudson Bay Lowland	Lower Fraser
	2:40-2:50pm	Bill Keller (LU), Day 2 Wrap Up	Lower Fraser

Science For a Changing North II

Agenda for Day 1

Wednesday, Feb. 23, 2011, Fraser Auditorium, Laurentian University

8:00 - 9:00 Registration, poster set-up, coffee and muffins

Session A: Developing Knowledge of the Far North (Open session)

9:00-9:15 **Dominic Giroux** (President LU), Welcome
9:15-10:00 **David Pearson** (LU), "Science in a Changing Far North" – Recommendations of the Far North Science Advisory Panel

10:00-10:30 Coffee and Poster Session (Fraser lobby)

Session B: Far North Natural and Cultural Resources

10:30-11:00 **Bill Keller** (LU), Aquatic Resources in Northern Ontario: Science Needs, Challenges and Opportunities
11:00- 11:30 **Andy Fyon** (OGS/MNDMF), Ethical Engagement and Science – Paradox or Synergy, Ontario's Far North
11:30-12:00 **Dianne Corbett** (MNR), The Far North Land Use Planning Initiative: Making Wise Decisions About Conservation and Resource Development Opportunities

12:00 -13:00 *Lunch and Poster Session (Alumni Hall)*

Session C: Policy and Planning: Ring of Fire and Beyond

13:00-13:30 **Christine Kaszycki** (MNDMF), Ring of Fire: Opportunities for Northern Ontario
13:30-14:00 **Glenn Nolan** (Noront Resources), Approach to Aboriginal Engagement (Abstract unavailable)
14:00-14:30 **Doug Morrison** (CEMI), New Technologies and Approaches for Environmental Sustainability

14:30-15:00 *Coffee and Poster session (Fraser lobby)*

Session D: **Science and Technology (continued February 24th)**

15: 00-15:30 **Tom Johnston** (MNR/CFEU), Mercury Contamination of Northern Fishes
15:30-15:50 **Nadia Mykytczuk** (McGill), Microbial Communities in the Canadian high Arctic: Early Insights into a Changing Climate
15:50-16:10 **Dean Millar** (LU/ MIRARCO), Permafrost Melt Experiment – Innovative Engineering Designs

16:10-16:30 **John Gunn** (LU) Day 1 Workshop Wrap Up

16:30-17:30 *Poster Social with Refreshments(Fraser lobby)*

17:30-19:00 Dinner featuring Guest Speaker **Norman Yan** (York) (Alumni Hall)
"Highlights of the Water Forum in Advance of the G8 Meeting"

"Science in a Changing Far North"
Recommendations of the Far North Science Advisory Panel

Pearson, D.
Cooperative Freshwater Ecology Unit, Laurentian University

No one has the luxury of time in the Far North. The climate is changing so rapidly that transportation on winter roads is becoming a lottery; hunting and fishing necessary for subsistence are being disrupted by changing migration patterns and concern over contamination; planning to meet all manner of socio-economic challenges is being driven at breakneck speed; tantalizing potential for benefitting from mineral resources seems to be a mirage without a pathway to reality; and the frustrated expectations of young First Nations people unable to see their place in the world are just beneath the surface. The bridge between doing science and making decisions in the Far North cannot be left to chance. Politicians speak of "getting it right". What does that mean and how can science and scientists best contribute?

The Far North Science Advisory Panel made the following recommendations:

1. **Create a coordinated government-wide strategy for the management of interim and on-going development**
2. **Immediately designate the "Ring of Fire" as a priority management area with an interim sub-regional planning process**
3. **Immediately establish the "Far North Land Use Strategy"**
   i) conduct land use planning to protect ecological integrity of the region as a whole while also achieving socio-economic objectives;
   ii) mitigate climate change by preventing or minimizing the loss of carbon storage in biomass and soil;
   iii) consider the impacts of climate change in land use planning;
   iv) establish a framework for protecting areas of cultural and ecological significance;
   v) use watersheds or other natural boundaries as the basis for establishing protected areas;
   vi) coordinate planning and management across administrative boundaries.
4. **Plan development incrementally, in a considered, proactive fashion**
   i) assess and manage cumulative impacts;
   ii) maintain the existing moratorium on large scale hydro-electric development and extend it to include inter-basin water diversions;
   iii) plan transportation and transmission corridors in a coordinated fashion, recognizing community needs and protecting significant ecological features;
   iv) prevent the introduction of invasive species.
5. **Apply the best continuous learning approaches through adaptive management**
   i) base management decisions on the best available knowledge but regularly revisit and revise strategies as the knowledge base improves;
   ii) support planning and management with an appropriate decision-support system.
6. **Provide communities and governments with the necessary information resources for planning and management**
   i) create a Far North information system to facilitate the use of best available knowledge, including Aboriginal Traditional Knowledge;
   ii) improve the available information base through a comprehensive inventory, enhanced monitoring, and special studies.

Aquatic Resources in Northern Ontario: Science Needs, Challenges and Opportunities

Keller, B.
Cooperative Freshwater Ecology Unit, Laurentian University

The Far North of Ontario is a unique landscape, with huge resources of freshwater draining to the marine environments of Hudson and James Bays. Oceans are a major part of the global carbon cycle and it is likely that climate change will substantially alter the storage and cycling of carbon in our northern ocean environments as ice cover changes, waters warm, and carbon exports from the land change. These changes will have profound effects on regional climate with resulting impacts on inland waters. Ontario's far north, at the interface of the vast peatlands of the Hudson and James Bay Lowlands (the third largest wetland complex in the world) and the marine environment, is a globally significant area.

The north is a vast, remote and sparsely populated area containing thousands of lakes. While lakes in Northern Ontario, particularly in the Far North, are among the most unaltered in North America, these systems are threatened by a variety of stressors. The rich natural resources of the north are attracting increasing attention for forestry, mineral extraction and hydroelectric development with associated risks to aquatic ecosystem integrity. Waters in the north are also particularly vulnerable to changes in climate. These ecosystems are well adapted to a cold, harsh climate with a short growing season. A warmer, drier climate is expected to fundamentally alter the nature of many of these waters in ways we can not yet predict. Information on lakes and rivers in the north is limited. To understand how these systems are likely to change in the future and how to protect them we need to better understand what they are like now and how they have changed in the past.

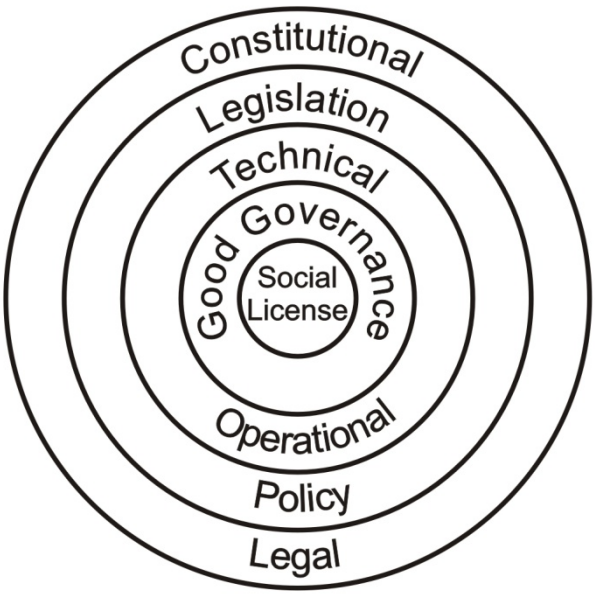
The protection and wise use of waters in the north of Ontario will require good information upon which to base decision making. Conducting the scientific studies needed to understand waters in the north and assess future risks will be challenging. It will demand a multidisciplinary approach and effective collaboration between researchers and stakeholders in the north. While current information is limited it is very important that existing knowledge be synthesized to guide further work. New surveys need to be implemented to describe the basic nature and variety of lake and river habitats and the biological communities they support. Paleoecological studies are needed to reveal the changes that have occurred and help forecast what is likely to happen in the future. Monitoring stations need to be established to allow us to detect changes as they happen in northern waters. New remote monitoring approaches need to be developed to create effective monitoring networks in this vast landscape. Experiments are needed to test hypotheses about potential future changes. Work has already been initiated to address many of the above elements in some regions of Northern Ontario, but much more is needed.

Ethical Engagement and Science – Paradox or Synergy, Ontario's Far North

Fyon. A.
Ontario Ministry of Northern Development, Mines and Forestry

Conducting science studies in Ontario's Far North requires careful planning, logistical and organizational co-ordination, but most importantly, requires a commitment to ethical engagement with Aboriginal people at a community level.

Engagement with Aboriginal people is an essential element of meeting constitutional duties to consult, of meeting legislative and policy objectives, and as a means to realize technical and operational efficiencies and insights. Ethical engagement incorporates these, as well as elements of good governance. An ethical engagement approach increases the potential to lay a foundation where science, having mutual interest and benefit, proceeds under an earned and strong social license granted by an Aboriginal community. Pragmatically, the operational reality of the Far North is different because of geographic isolation, historic factors, and Aboriginal governance and cultural practices. To conduct science in this context requires an adaptive and sustained investment in meaningful communication, relationship-building, mutual learning, and respect, while seeking mutual interests and synergies. The desired outcome is not just the immediate science result, but is a long-term legacy where traditional knowledge and science realize their complementary potential to yield a rich and holistic view of the subsurface and surface of the Earth.



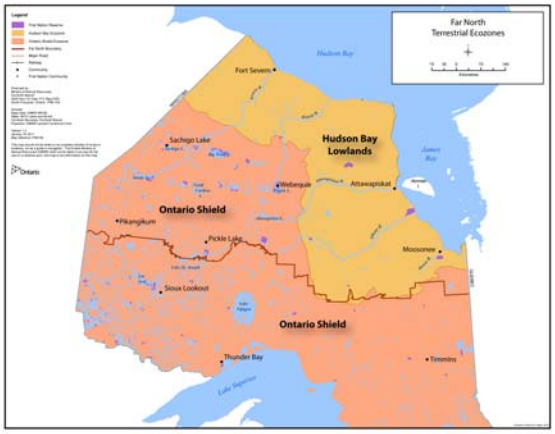
Schematic of ethical engagement continuum.

The Far North Land Use Planning Initiative: Making wise decisions about conservation and resource development opportunities

Dianne Corbett
Director, Far North Branch, MNR

Occupying 42% of the province's land mass, the Far North is a vast, largely undeveloped and important part of Ontario. It is also home to the many First Nation people who have lived there for generations. Its forests, wetlands, lakes and natural resources make a priceless contribution to the natural health and wealth of Ontario. The natural resource potential has brought increasing pressure for new resource development. To respond to such pressures and to help protect the ecology and vast boreal environment of the region, the Far North Land Use Planning Initiative provides a foundation to work with First Nations in the Far North in making wise land use decisions. In 2010, Ontario passed the *Far North Act*, which sets out an objective to protect at least 225,000 square kilometres of the Far North in an interconnected network of protected areas through community based land use planning, while enabling new opportunities for sustainable economic development. Supporting wise land use decisions also means investing in important science and information work in the Far North through the Ministry of Natural Resources' Information and Knowledge Management Plan. Ultimately, Ontario's vision for the Far North is one where wise land use planning decisions recognize the social, environmental and economic interests of both First Nations and Ontario.

Fen peatlands in the Far North of Ontario.
photo by Zaid Jumean



Ecozones of the Far North of Ontario

The Ring of Fire
Opportunities for Northern Ontario

Kaszycki, C.
Ministry of Northern Development, Mines and Forestry

The "Ring of Fire" initiative refers to one of the most promising development opportunities in Northern Ontario in perhaps a century. Located in Ontario's Far North, current estimates from companies exploring in the area suggest the potential for decades of chromite production, as well as significant production of nickel, copper and platinum.

Although still in the exploration stage, mineral production potential could be on the scale of historic world class mining areas such as Sudbury, Timmins, Kirkland Lake, Red Lake, all of which have seen mineral development spanning a century of production. An initiative of this scale and scope provides a historic opportunity to think strategically & plan for economic development in an environmentally and socially sustainable manner, including but not limited to: strategic infrastructure planning, value-added processing, First Nations engagement and economic development opportunities, community capacity and social supports, and training and employment.

The Ring of Fire initiative forms a key pillar of Ontario's Open Ontario plan and will also build on the current provincial policy framework including: Northern Growth Plan, Far North Land Use Planning, Green Energy Act, and Mining Act Modernization.

New Technologies and Approaches for Environmental Sustainability

Morrison. D.
Centre for Excellence in Mining Innovation

Environmental sustainability in the North is part of the global context. Resource industries now have to produce as much base metal, steel and energy than has ever been produced before. Deposits are harder to extract and process and it is slower and more costly to bring new, remote resources to market. We have to reduce the environmental impact of existing and future operations, while climate change makes it increasingly difficult to supply remote production sites with water, power and materiel. We have to enhance the economy and social fabric of communities living close to natural resources while we sustain the expansion of developed economies.

Mercury Contamination of Northern Fishes

Johnston, T.
Cooperative Freshwater Ecology Unit, Ministry of Natural Resources

Mercury is a neurotoxin and contaminant of concern in many aquatic and marine ecosystems. Among the metals, it has several unique properties that affect its biogeochemical cycling, and allow it to both bioaccumulate and biomagnify in food webs. Piscivorous fish contain particularly high mercury concentrations because they are at the end of long food chains. Consumption of piscivorous fish is the primary route of mercury exposure in humans. Mercury concentrations in aquatic biota depend on environmental factors influencing the production of methylmercury, the bioavailable form, and ecological and physiological factors influencing its uptake. Anthropogenic stressors may act on one or more of these factors. Elevated fish mercury levels in northern waters have been associated with point-source mercury discharges, reservoir development, and atmospheric mercury deposition. Fish mercury is an issue of particular concern in Northern Ontario because of the importance of fish as a local food source, and because fish mercury concentrations are typically higher in northern waters due to slower growth rates. Elevated fish mercury concentrations also limit opportunities for commercial fishery development due to marketing restrictions. Northern development, climate change, and alterations in global mercury cycles could all influence northern fish mercury concentrations in future.

Microbial Communities in the Canadian High Arctic: Early Insights into a Changing Climate

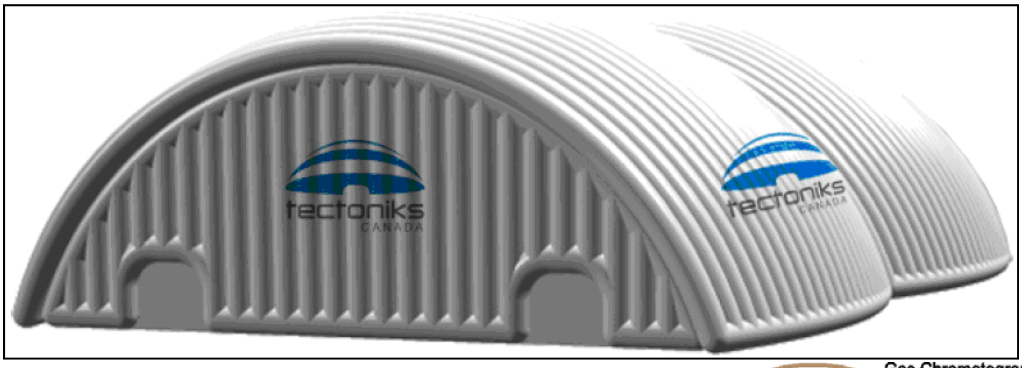
Mykytczuk, N.C.S.[1], Martineau, C.[1,2], Yergeau, E.[1,2], Allan, J[1], Greer, C.W.[2], Whyte, L.G.[1].
[1]McGill University, [2]National Research Council of Canada

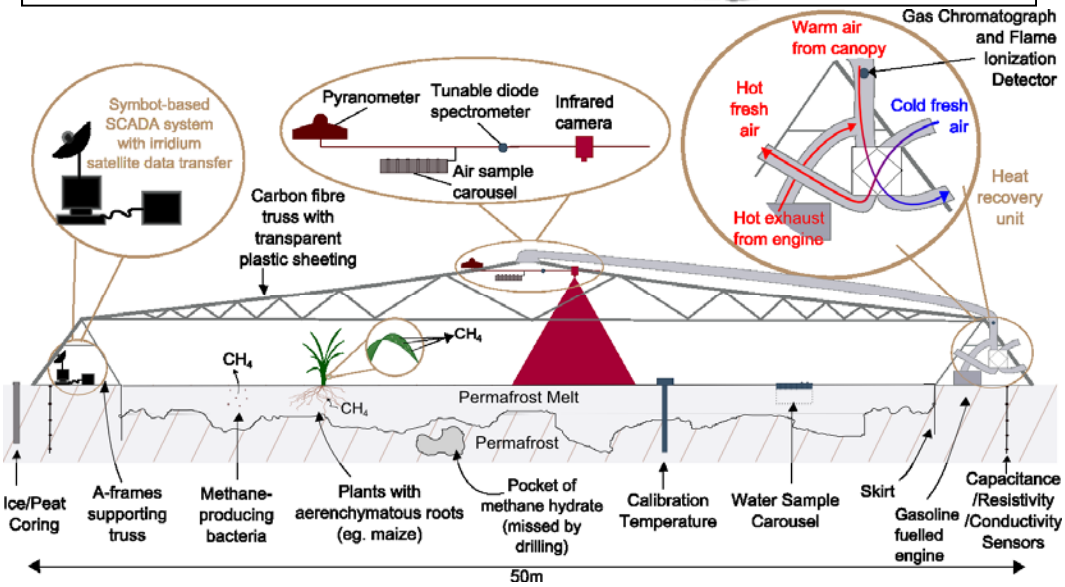
Warming associated with climate change is expected to be most severe in the Earth's polar regions, leading to potentially extensive thawing of these (subzero) cryoenvironments. As permafrost thaws, organic matter will become increasingly accessible for microbial degradation, and with increased microbial activity the potential for release of large amounts of greenhouse gases: CO_2 and CH_4. Our recent research on Axel Heiberg and Ellesmere Islands in the Canadian high Arctic is investigating microbial communities in various cryoenvironments including hypersaline perennial springs and thick (~600m) extensive permafrost. The overall goals are to determine the composition and genetic potential of the microbial communities, their activity in situ and with increasing temperature. An array of molecular techniques including PCR-based, metagenomic, radio-labeled respiration assays, and stable-isotope probing of nucleic acids have been employed in characterizing the bacterial and archaeal diversity and activity with particular focus on the carbon cycle; microbial CO_2 production, CH_4 generation and oxidation. Total increases in CO_2 production are driven by total microbial abundance which is highest in the permafrost active layers. In particular the abundance of copiotrophic bacterial taxa in permafrost with high organic matter could lead to rapid increase in CO_2 production with warming. Methane production by archaeal methanogens along with the potential for *in situ* microbial attenuation of CH_4 release via oxidation (methanotrophy) exists within all of the permafrost soils tested. DNA-stable isotope probing and quantitative-PCR shows that both the diversity and abundance of active methanogens in the permafrost tested are quite low. However increases in temperature to, 4 and 15°C caused higher rates of methane production as well as increases in methane oxidation in separate microcosm experiments. For methanotrophs, potential methane oxidation rates were correlated with the abundance of specific bacterial taxa (i.e. Upland Soil Cluster γ). Both diversity and abundance of methane-metabolizing groups in the permafrost soils vary with distinctive physico-chemical characteristics (organic carbon, pH, water/O_2 content). Metagenome analyses of active layer and 2m deep permafrost reveal a diverse and surprisingly abundant *in situ* genetic potential for methane generation and oxidation (i.e. *pmoA*), along with organic matter degradation, nitrogen fixation, and ammonia oxidation that could have important roles following climate change in these nutrient and nitrogen-limited environments. As the microbiology of permafrost remains relatively unexplored, the insights from several related studies provide the basis for understanding in situ metabolic potential and the possibility of enhanced microbial activity under increasing temperature regimes.

Dynamic Response of Permafrost to Induced Thaw

Millar, D.
Energy, Renewables & Carbon Management (ERCM), &MIRARCO Laurentian University

This research will undertake large scale empirical observations to investigate the most pressing issue faced by Canada's North: how will continuous permafrost regions respond to climate change induced thaw? The research effort centers on the design, development, deployment and operation of a large scale, temporary, research structure in the continuous permafrost zone, close to the shoreline of Hudson Bay. This transparent, inflatable, building will form an enclosed plenum approximately 50m x 35m in area and will use incident solar radiation to deliberately induce a rapid, yet controlled, thaw of the ground beneath it. As the permafrost thaw develops, the structure will capture and meter gaseous effluxes, and sample the plenum atmosphere and melt water. The work will produce badly needed direct empirical evidence of the dynamic response of this polycryogenic system to higher atmospheric temperatures and the consequences of permafrost thaw, at a scale that aims to ensure key phenomena are properly represented and uncertainties characterized.





Rendering of inflatable building design to be adopted in the research, produced by Tectonics Canada Inc., (above) and schematic cross section through structure illustrating heat recovery, instrumentation and sampling systems (below).

Science For a Changing North II

Agenda for Day 2 –Science and Technology

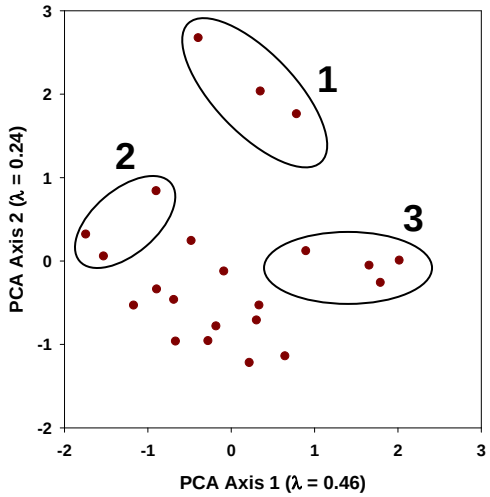
Thursday, Feb. 24, 2011, Fraser Auditorium, Laurentian University

8:30-8:50	**Andrew Paterson** (MOE), A Review of Water Quality and Phytoplankton from Lakes in the Hudson Bay Lowlands, Northern Ontario
8:50-9:10	**Kathleen Rühland** (Queens), Recent Changes in Diatoms and Other Paleoindicators from Lakes in the Hudson Bay Lowlands, Northern Ontario Over the Last ca. 100 years
9:10-9:30	**Michelle Brazeau** (Ottawa), Characterization of Lake Sediment Microbial Communities in a Warming Climate and Their Impact on the Mercury Geochemical Cycle
9:30-9:50	**John Gunn** (LU), Climate Warming Effects in Subarctic Rivers: Building on Traditional Knowledge
9:50-10:10	**Chris Jones** (MOE), Benthic-invertebrate Communities in Lakes and Streams of Ontario's Far North (Sutton Ridge and Hudson Bay Lowlands)
10:10-10:40	*Coffee (Fraser lobby)*
10:40-11:00	**Derek Mueller** (Carleton), Remote Sensing in the Far North: Detecting and Evaluating Environmental Change in the Coastal Cryosphere
11:00-11:20	**Sarah Finkelstein** (Toronto), Paleoclimates, paleoecology and Biogeochemistry in Ontario's Hudson Bay Lowlands
11:20-11:40	**Brent Wolfe** (Wilfrid Laurier), Isotopic Approaches for Characterizing Present and Past Hydrology of the Western Hudson Bay Lowlands
11:40-12:00	**Shelley Arnott** (Queens), The Impact of Environmental Change on Aquatic Communities in Wapusk National Park
12:00-13:00	*Lunch (Alumni Hall)*
13:00-13:20	**Chris Charron** (MOE), Carbon Flux Monitoring in the Hudson Bay Lowlands
13:20-13:40	**Jeff Amos** (MNR), Ontario's Broad-scale Lakes Monitoring Program: Design and Initial Results
13:40-14:00	**Steve McGovern** (MNR), Far North Aquatic Science Projects: MNR/NESI Preliminary Investigations under the Far North Information and Knowledge Management (FN-IKM) Initiative
14:00-14:20	**Peter Barnett** (MNDMF), Remote Predictive Mapping of Surficial Materials in the Far North of Ontario
14:20-14:40	**Katherine Garrah** (LU), Determining Soil-Plant Reference Conditions for the Reclamation of Mine Stockpiles in the Hudson Bay Lowland
14:40-14:50	**Bill Keller** (LU), Day 2 Wrap Up

A Review of Water Quality and Phytoplankton from Lakes in the Hudson Bay Lowlands, Northern Ontario

Paterson, A.M. [1], *Keller, W.* [2], *Jones, F.C.* [1], *Rühland, K.M.*[3], *and Winter, J.G.*[1]
[1] *Ontario Ministry of the Environment;* [2] *Laurentian University;* [3] *Queen's University;* [4]

The Hudson Bay Lowlands (HBL) of Northern Ontario forms part of one of the most extensive peatlands in the world. Its location at the southern edge of the zone of continuous permafrost in Canada makes the region particularly sensitive to climatic change, with uncertain implications for local and regional hydrological processes, carbon dynamics, and biodiversity. Despite its vast size, and the numerous ponds and lakes that exist across the landscape, little is known about the general limnology of aquatic ecosystems in the region. Thus, our purpose was to provide a first characterization of limnological conditions of several lakes in the northern HBL, providing a foundation upon which broader spatial and temporal studies could be initiated. In the summers of 2009 and 2010, we collected water chemical and biological data from 11 lakes, five of which were sampled in both years. Principal components analysis (PCA) of water chemical data showed that sites separated into three broad groupings, with shallow coastal, shallow inland, and deeper inland lakes showing distinct chemical conditions. Sampling of five lakes in both years showed that all of the lakes were generally more transparent and alkaline in 2010, possibly linked to differing weather. However, the relative positioning of lakes in ordination space did not change over time, suggesting that useful interpretations can be made from the spot chemistry samples collected. In 2009, water samples were also collected for detailed phytoplankton analysis. The lakes varied in community composition and algal abundance, with the highest abundances recorded in the large, shallow inland lakes. These lakes were dominated by higher relative biovolumes of cyanobacteria and green algae.



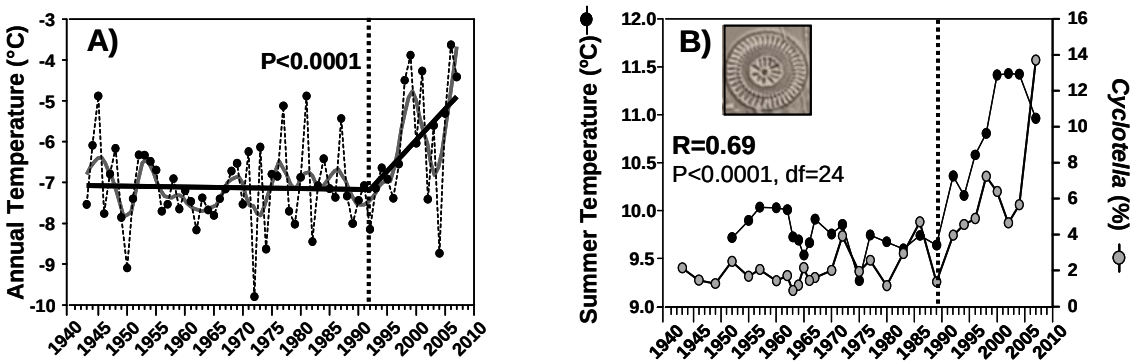
PCA of water chemistry data, showing the separation of the study lakes. Shallow coastal (1), shallow inland (2), and deeper inland (3) lakes showed distinct groupings, based on water quality.

Recent Changes in Diatoms and Other Paleoindicators from Lakes in the Hudson Bay Lowlands, Northern Ontario over the Last ca. 100 Years

Rühland, K.M.[1], Paterson, A.M.[2], Keller, W.[3], Michelutti, N.[1], and Smol, J.P.[1]
[1]Queen's University; [2]Ontario Ministry of the Environment; [3]Laurentian University

Historically, the Sutton River region of the Hudson Bay Lowlands (HBL) has remained cool relative to the surrounding area, largely because this is the last portion of Hudson and James Bay to become free of sea ice in the spring. However, in the last two decades the HBL has undergone unprecedented increases in air temperature. To examine whether this new extreme warming regime is affecting freshwater lakes in the HBL region, we examined changes in diatoms and other paleolimnological proxies over the last century from dated sediment cores.

Sedimentary diatoms were scarce in our study lakes prior to the ca. mid-20th century, after which diatom assemblage composition underwent notable changes, and the relative abundances of siliceous phytoliths decreased. Concurrent with these changes, anomalies in sedimentation rates and magnetic susceptibility were recorded synchronously in our lakes. Possible mechanisms for this abrupt, mid-century change are examined. The most prominent shift in the biological proxies occurred in the last ca. two decades, when planktonic diatoms and scaled chrysophytes increased in relative abundances together with sedimentary chlorophyll *a*, whereas benthic fragilarioid diatoms declined further. Such changes have previously been linked to decreased lake ice cover and/or increased thermal stratification (Rühland et al., 2008, Global Change Biology, 14:2740–2754). Strong and significant correlations were observed between Churchill temperature data and overall diatom compositional changes, summarized through principal components analysis. Equally striking were significant taxon-specific relationships to temperature trends with positive correlations to increases in planktonic diatoms, and negative correlations to decreases in benthic fragilarioid diatom taxa. To date, our results indicate that the onset of marked warming ca. 1990s in the HBL region has triggered a notable biological response in the algal communities of our study lakes.



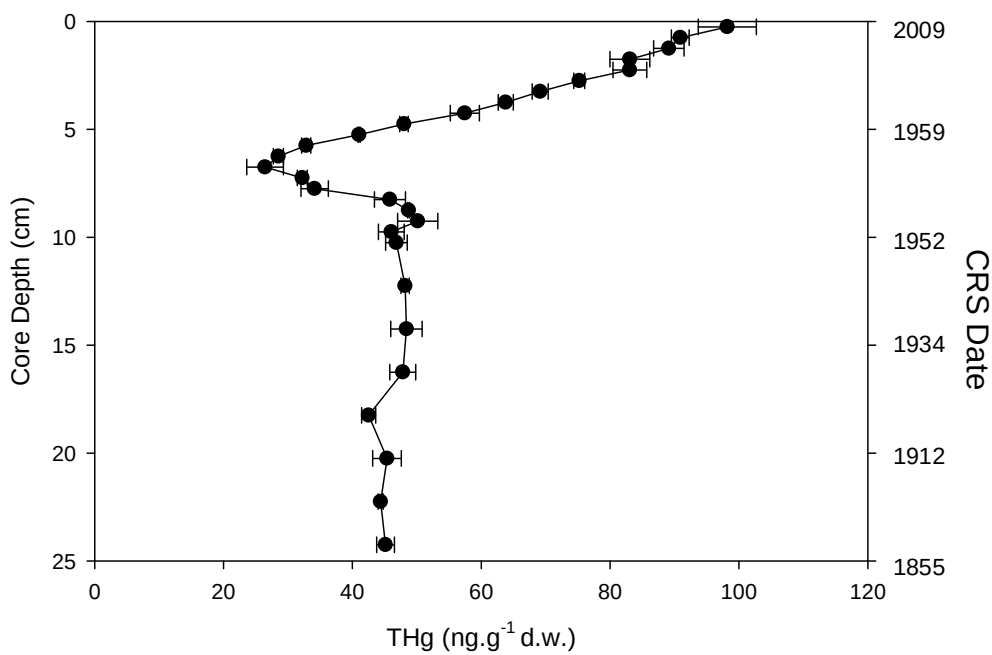
A) Mean annual temperature trends, Churchill, Manitoba, since A.D. 1940. A LOESS smoother was applied to the temperature data (grey line); dashed vertical line indicates significant breakpoint ca. 1992 determined using a piecewise linear regression. **B)** Churchill mean summer temperature versus percent relative abundances of planktonic *Cyclotella* taxa, North Raft Lake (54º32'4.0"N, 84º45'21.6"W).

Characterization of Lake Sediment Microbial Communities in a Warming Climate and their Impact on the Mercury Geochemical Cycle

Brazeau, M.L.[1], Poulain, A.J.[1], Blais, J.M.[1], Keller, B.[2] and Paterson, A.[3]
[1]University of Ottawa, [2]Cooperative Freshwater Ecology Unit, Laurentian University
[3]Ontario Ministry of the Environment

Climate change is a global phenomenon but its repercussions may be greatest in polar and sub-polar ecosystems. In Northern Ontario, recent climate warming has led to changes in aquatic ecosytems. In an effort to understand the changes occurring in these lakes, a collaboration has been initiated between researchers from the Ontario government and a number of universities, including the University of Ottawa. Water and sediment cores have been collected from 14 lakes in the Hudson Bay Lowlands area. Using these samples, our objective is to assess, through time, the changes occurring in i) the microbial communities of these lakes and ii) the geochemical cycle of mercury. Mercury is a contaminant of particular concern for lakes in the north given its effect on the edibility of fish and the potential changes in mercury availability that may occur with a changing climate.

Preliminary results show a drastic increase in mercury concentrations within the lake sediments despite their remote location. The presence of the *mer* operon, the mercury resistance gene, has also been confirmed in sediments from one of these lakes. Subsequent work is underway to determine if mercury reducing bacteria are active; thus potentially changing the way mercury profiles in lake sediments should be interpreted.

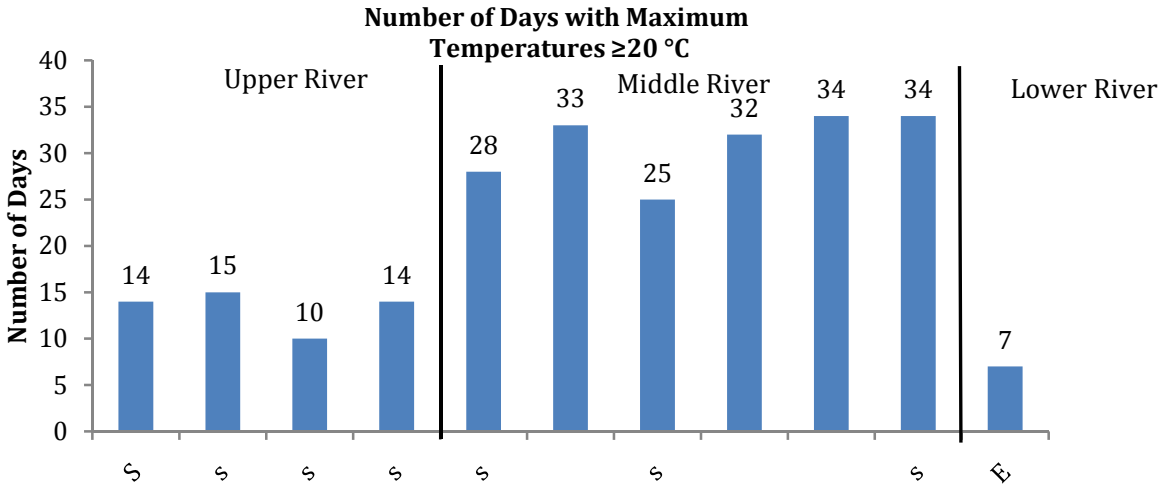


Total mercury (THg) profile ($ng \cdot g^{-1}$ d.w.) of a sediment core from Hawley Lake (n = 3 ± SE) and ^{210}Pb dates according to the Constant Rate of Supply Model.

Climate Warming Effects in Subarctic Rivers: Building on Traditional Knowledge

Gunn, J.[1], Johnston, T.[1], Chookomolin, A.[2], Chookomolin, G.[2], and Keller, W.[1]
[1]Cooperative Freshwater Ecology Unit, Laurentian University, [2]Weenusk Fist Nation

The Hudson Bay rivers are important sources of food for coastal First Nations communities in the form of anadromous stocks of whitefish and brook trout. These migratory fish feed heavily in the marine environment before returning to the freshwater to reproduce and overwinter. Anadromous fish are not only a highly nutritious food source but they also tend to have lower levels of Hg and other contaminants than do freshwater forms. Current climate models suggest that these northern ecosystems are particularly vulnerable to extreme temperature changes through rapidly rising air temperatures as well as the loss of the moderating effects of sea ice. Expected increases in evaporation and a shift to more rain in winter and earlier spring runoff, as well as the potential release of Hg from melting permafrost and drying wetlands, all combine to create uncertainty and worry about the future of these valuable anadromous stocks. However, the precision of model predictions in such complex systems can be very low and there is a pressing need for more direct survey data and monitoring of trends. Here, traditional knowledge (TK) can provide the important starting points for such studies, and local observations can also profoundly change the questions ecologists ask. For example, in the Sutton River, local community members identified warming and drying trends that has been associated with recent mortality impacts on migratory trout (Gunn and Snucins 2010, Hydrobiologia 650:79-84), but they also suggested that the habitat in the river was changing (more weed growth) and that northern pike were now abundant in this famous brook trout river. The arrival or expansion of pike, a potential competitor or predator, with a wider thermal tolerance than trout, represents a phenomenon much like the northern movement of warm water smallmouth bass into coldwater lake trout lakes. This presentation provides preliminary findings from a collaborative project in 2010 designed to follow up on these local observations by conducting a detailed thermal survey of this 120 km river and a sampling of pike throughout the system for analysis of Hg and stable isotopes.

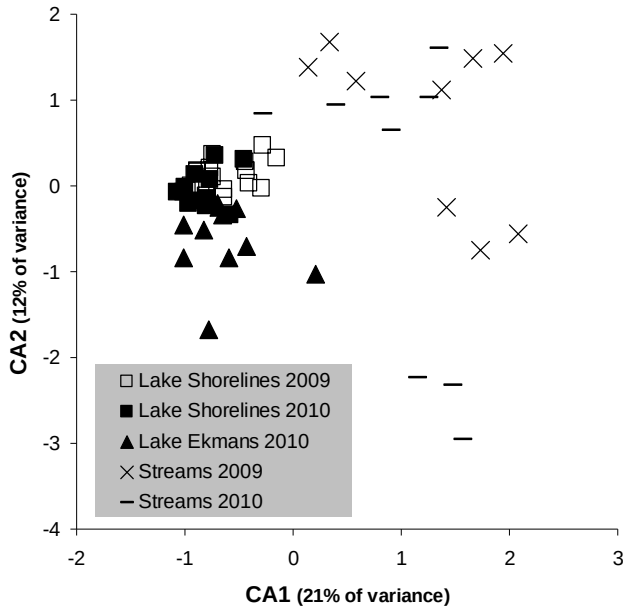


Number of days with maximum water temperature above preferred temperature for brook trout (≥20˚C) at sites on Sutton River, 2010.

Benthic-invertebrate Communities in Lakes and Streams of Ontario's Far North (Sutton Ridge and Hudson Bay Lowlands)

Jones, F.C.[1] and Sinclair, S.[2]
[1]Ontario Ministry of Environment, [2]Saugeen Valley Conservation Authority

Thousands of samples have been collected in southern Ontario's lakes and streams, making their benthic ecologies relatively well described. Some important questions (e.g., about normal ranges of variability, and index responses to stress) do remain unanswered, but sufficient knowledge has been gained to allow standard methods for Ontario's Benthic-invertebrate Biomonitoring Network (OBBN) to be published. In contrast, relatively little is known about the benthic ecology of Ontario's Far North. Before biomonitoring can be used to track ecological conditions in these remote areas, basic questions about biodiversity and community variability need to be answered. As a start, exploratory surveys of 11 lakes and 4 streams were conducted in 2009 and 2010, using OBBN methods. In 2009, benthic invertebrates in the littoral zones of North Raft and Hawley Lakes (both situated on the Sutton Ridge, in Ontario's extreme north-east), and in three tributary streams of Hawley Lake, were surveyed. In 2010, surveys of Hawley Lake and its tributaries were repeated, and additional samples were collected in the Sutton River (Hawley Lake's outflow). That same year, profundal communities in 9 lakes, situated in the Hudson Bay Lowlands around the periphery of the Sutton Ridge, were also sampled. In total, 71 families of benthic invertebrates were encountered. Richness was stable between 2009 and 2010 in Hawley lake and two of its tributaries. With respect to the different waterbodies sampled, streams were most taxonomically rich (mean = 15 families), and profundal lake samples contained the fewest taxa (mean = 7 families). A Correspondence Analysis ordination of taxa counts distinguished stream and lake communities, and illustrated some compositional changes in the shoreline communities of Hawley Lake that occurred between 2009 and 2010.

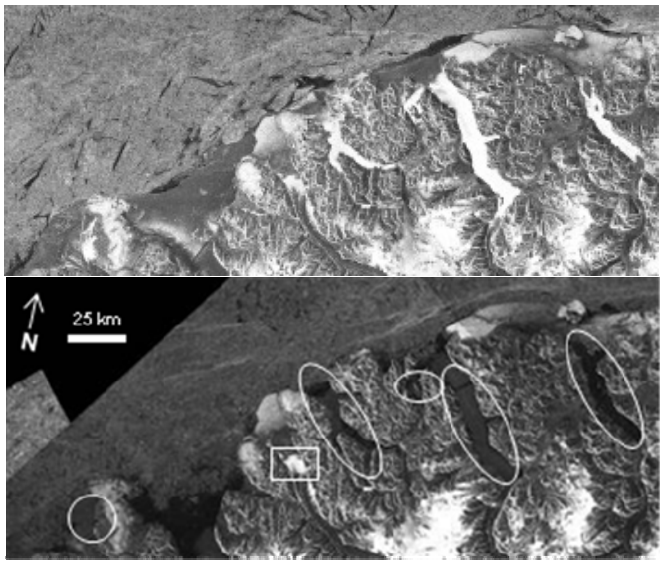


Correspondence analysis of log-transformed benthic-invertebrate taxa counts from 11 lakes and 4 streams (lake and stream samples are distinguished along the first CA axis).

Remote Sensing in the Far North: Detecting and Evaluating Environmental Change in the Coastal Cryosphere

Mueller, D.
Carleton University

Cryospheric features along the northern coastline of Ellesmere Island have undergone dramatic environmental change over the last decade. This includes the loss of 214 km^2 of Canada's ice shelves – a thick (~40 m) and ancient (3000-5500 years-old) ice type that used to fringe most of the coastline. Two ice shelves calved completely in 2005 and 2008 and large portions of the remaining four broke away in the summer of 2002, 2005, 2007, 2008 and 2010. Unique epishelf lakes, formed by the presence of thick coastal ice, which impounds freshwater in fiords, have drained as a result of ice shelf break-up. At the same time, perennially ice covered lakes are shifting to a new seasonally ice-free regime. The use of remote sensing technology to complement field measurements has revealed insights into the timing and spatial extent of these changes in a region which is difficult to access. Synthetic aperture radar imagery is particularly useful for examining changes in ice extent and type. For example, ice shelf extent can be readily distinguished from sea ice and ice loss on perennially ice covered lakes can be determined up to several months following their breakup. The presence of epishelf or ice-dammed lakes is discernable due to high backscatter in the overlying ice (see figure below). This region of Canada has warmed at ~0.5^{o}C per decade (over 60 years) and is projected to warm by another 5°C over this Century. Remote sensing will undoubtedly play a key role in detecting and evaluating further environmental change to these cryospheric features and their dependent aquatic ecosystems.

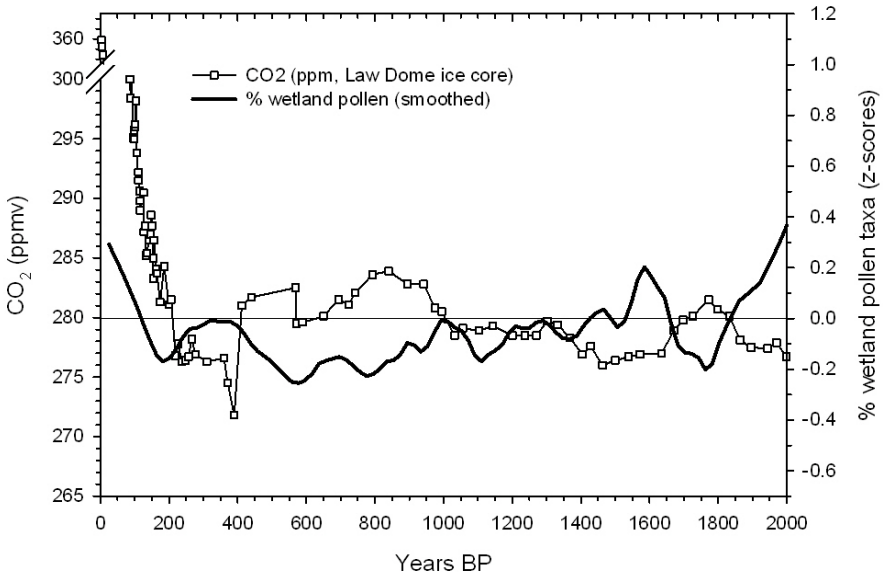


Synthetic aperture radar images of the northern coast of Ellesmere Island, Nunavut from mid-winter 2002 (above) and 2009 (below). A change from high backscatter (bright) to low backscatter (dark) over this time interval indicates the loss of all (white ovals) but one (white square) of the epishelf or ice-dammed lakes that have occupied fiords and bays for up to thousands of years. RADARSAT-1 Data were provided by the Alaska Satellite Facility, © 2002 Canadian Space Agency; RADARSAT-2 Data and Products © 2009 MacDonald, Dettwiler and Associates Ltd. - All Rights Reserved.

Paleoclimates, Paleoecology and Biogeochemistry in Ontario's Hudson Bay Lowlands

Finkelstein, S.A.
University of Toronto

Wetlands play a critical role in the global carbon cycle through storage of carbon under waterlogged conditions and emission of methane due to anaerobic metabolism. We synthesized North American pollen records to show a correlation between wetland dynamics in the Holocene and fluctuations in the concentrations of atmospheric greenhouse gases (see Figure), suggesting that wetlands are important to consider in models of global climate-biosphere feedbacks. The extensive peatlands of Ontario's Hudson Bay Lowlands (HBL) are a globally significant repository of carbon, but more information is needed on the sensitivity of these peatlands to hydro-climatic change. To that end, we are using paleoecological archives to measure the responses of HBL peatlands to environmental changes. Radiocarbon dating and bulk density measurements on a series of peat cores spanning the lowlands permit estimates of the current carbon pool. Detailed paleoecological studies of individual peat cores are being conducted using a variety of biological indicators to reconstruct vegetation communities and water table position since peatland initiation in the mid-Holocene (~6000 yrs ago). Lake sediment cores from sites in the region are being used to produce independently generated paleoclimate records to isolate the role of climate changes during the Holocene from the effects of isostatic rebound and ecological succession on peatland development and carbon storage. Taken as a whole, these studies will improve Earth system models and enable predictions of future impacts of hydro-climatic change on carbon storage and vegetation dynamics in these important peatlands.



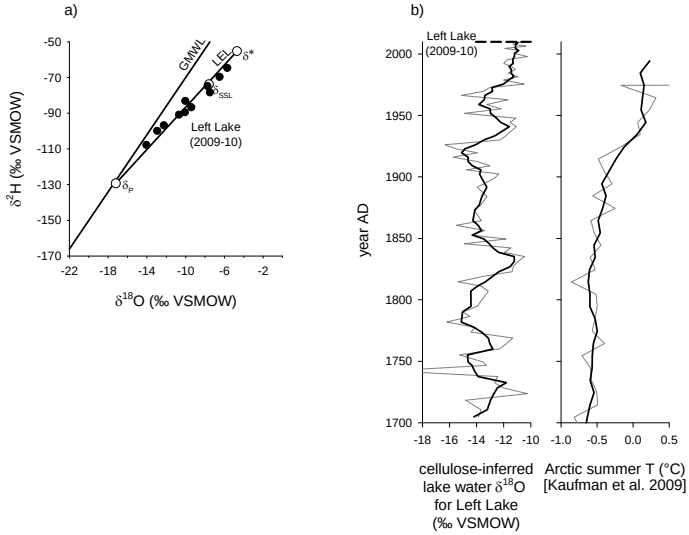
Lowess-smoothed time series of % wetland pollen taxa at 124 sites in temperate North America, pooled into 25-year bins, for the past 2000 years before present (BP) (data extracted from the North American Pollen Database), and atmospheric CO_2 concentrations for the same time period derived from the Law Dome ice core (Data from: MacFarling Meure et al., 2006, *GRL*). After Finkelstein and Cowling, 2011, *Glob Biogeochem Cycles*.

Isotopic Approaches for Characterizing Present and Past Hydrology of the Western Hudson Bay Lowlands

Wolfe, B.B.[1], Dobson, E.M.[1], Farquharson, N.M.[1], Eichel, K.[2], Hall, R.I.[2], Macrae, M.L.[3], Fishback, L.A.[4] and Sweetman, J.N.[5]

[1]Wilfrid Laurier University; [2]University of Waterloo; [3]University of Waterloo; [4]Churchill Northern Studies Centre; [5]Parks Canada

Shallow lakes are an important landscape element in the western Hudson Bay Lowlands (HBL) and provide critical habitat for wildlife. However, little is known about their hydroecology, how the lakes have responded to climate change and variability in the past, and how they will evolve in the future. Lack of baseline hydroecological information impedes assessment of the future availability of water resources in the western HBL. Research thus aims to characterize the relative importance of hydrological processes that govern present-day lake water balances, identify relationships among hydrology, limnology and aquatic ecology, and provide the basis to hindcast and predict changes in hydroecological conditions in response to climate change and variability. Spearheaded by the use of water isotope tracers, we have launched new hydroecological investigations in the Churchill area (2009) and Wapusk National Park (2010) of northeastern Manitoba. Results from lake water isotopic monitoring have revealed that lakes span a broad hydrological gradient associated with land cover vegetation. For instance, snowmelt effectively offsets evaporative loss in lakes situated in the interior boreal forest, whereas lakes in the coastal tundra tend to be much more highly susceptible to lake-level drawdown. Extreme evaporation in mid-summer 2010 led to desiccation of some coastal tundra lakes in our study set. Paleohydrological reconstructions from lake sediment cores, utilizing aquatic cellulose as an archive of lake water oxygen isotope history, illustrates that some coastal tundra and boreal-taiga transition lakes have undergone increasing evaporation relative to inflow over the past century, likely in response to warming. Our paleolimnological records also indicate a corresponding change in the nutrient status of lakes occurred during the 20th century characterized by increasing nitrogen availability, possibly due to anthropogenic supply of atmospheric nitrogen.

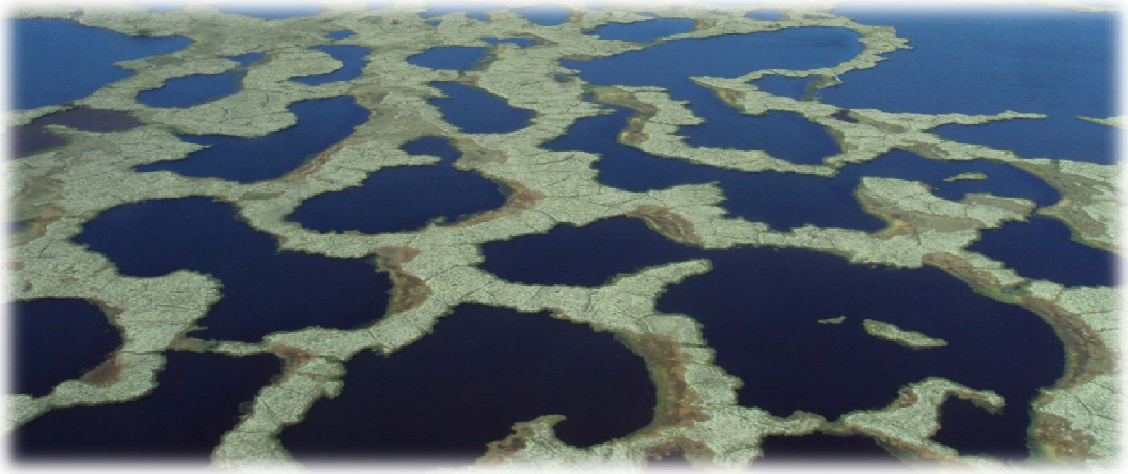


a) Lake water isotope composition of "Left Lake", a coastal tundra lake near Churchill, shifts along the Local Evaporation Line (LEL) in response to precipitation and evaporation.
b) Cellulose-inferred lake water oxygen isotope record for Left Lake indicates increasing role of evaporation during the 20th century, parallel to circum-Arctic warming.

The Impact of Environmental Change on Aquatic Communities in Wapusk National Park

Arnott, S.[1], Symons,C.[1,] Sweetman, J.[2], Hanschel, J.l[1], and Pedruski, M.[3]
[1]Queen's University, [2]Parks Canada, [3]McGill University

Subarctic regions are expected to experience dramatic changes in nutrient loading and conductivity as a result of large-scale regional factors such as climate change and population increases in migratory Snow Geese. The response of aquatic biota will depend on changes in the local environment as well as regional processes that influence lake connectivity and the movement of organisms among lakes. In an effort to understand how aquatic ecosystems in subarctic regions will respond to future environmental change, we have conducted a series of studies in Wapusk National Park in the Hudson Bay Lowlands. We performed nutrient enrichment bioassays in 21 ponds to assess nutrient limitation in the phytoplankton communities. These experiments revealed that in 62% of our study lakes phytoplankton were nutrient limited (N-, P-, or co-limited), indicating that predicted increases in nutrient loading will likely have large effects on primary production. This is further supported by experiments that suggested that zooplankton grazing on phytoplankton was low; an average of only 6% of the phytoplankton was grazed per day. Grazing rate was dependent on the biomass of cladocerans in the ponds; higher biomass of cladocerans resulted in higher grazing rates. However, pond survey results suggest that local adaptation of zooplankton to environmental change may be high because of high connectivity among lakes. High dispersal of zooplankton, particularly key species such as *Daphnia*, may mediate community and ecosystem responses to environmental change. Laboratory studies indicate that there are genotype-specific responses to environmental stressors (e.g., conductivity). This variation, combined with high dispersal rates may allow for adaptative responses of populations and communities to environmental change. This hypothesis will be tested this summer in a mesocosm experiment designed to investigate community and ecosystem response to two environmental stressors (nutrients and salinity) under different dispersal scenarios.



Aerial photograph of ponds in Wapusk National Park.

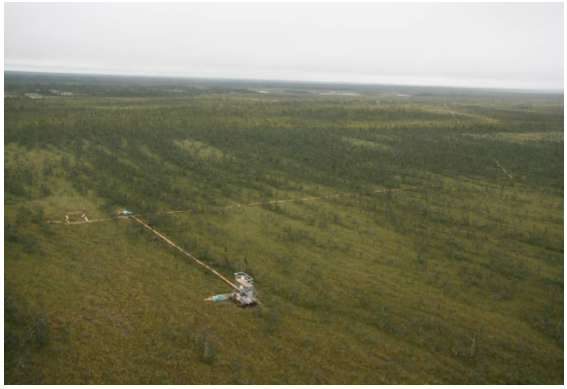
Carbon Flux Monitoring in the Hudson Bay Lowlands

Charron, C.
Ontario Ministry of the Environment

The Hudson Bay Lowlands is one of the largest peatland complexes in the world, second only to the Western Siberian Lowlands. The region is recognized as a globally significant carbon store and plays a critical role in protecting water quality and biodiversity at the provincial and national scale. This massive expanse of peatland contains approximately 35 gigatonnes of soil carbon – equal to approximately 12% of all the organic carbon stored in Canadian soils. Very little data exists for this part of Ontario however due its inaccesibility and the logistical challenges associated with operating in the Far North of Ontario. There is also a limited understanding of the potential impacts of climate change and other types of disturbance on this important carbon store.

The Ontario Ministry of the Environment has established two long term monitoring stations in the Kinoje Lakes and Attawapiskat River regions of the Hudson Bay Lowlands. These monitoring stations measure the exchange of carbon, water, and energy over peatland ecosystems using eddy covariance techniques to help address knowledge gaps and reduce the uncertainty of carbon budget estimates for the Far North of Ontario. Collected data will be used to improve our understanding of carbon cycling in the Hudson Bay Lowlands, to assess the potential impacts of climate change on greenhouse gas exchange, and to drive, validate, and refine models that predict ecosystem balances of carbon.

The Ministry's monitoring stations have been established in collaboration with First Nations, the Ontario Ministry of Natural Resources, academia, and industry. These partnerships facilitate the sharing of resources, expertise, and data, minimize operational costs, and optimize data collection and analysis activities. Partners are conducting additional research and data collection above and beyond the Ministry's mandate maximizing the return on the provincial investment. Collectively, these data will help provide a comprehensive characterization of the hydrology, biogeochemistry, and carbon dynamics of peatlands in these regions of the Hudson Bay Lowlands. The province will use this data to to assist in land use planning in the Far North and in the development of climate change adaptation and mitigation strategies.



Ontario's Broad-scale Lakes Monitoring Program: Design and Initial Results

Amos, J., Sandstrom,s, Armstrong K., Ball, H. and Lester, N.
Ontario Ministry of Natural Resources

The province of Ontario, with over 250,000 lakes and thousands of kilometres of rivers, supports a recreational fishery of two million anglers spending over 2.3 billion dollars a year on fishing-related expenses. In 2008, Ontario initiated a broad-scale lakes monitoring program aimed at reporting on the current and changing state of inland lake fishery resources. Within each fisheries management zone, a stratified random sample of lakes is used to assess the condition of fishery resources. The primary sampling components are: (1) a spring water chemistry survey, (2) summer depth-stratified index netting of the fish community, and (3) seasonal aerial surveys of angling activity. Reporting is done on a 5-year cycle. The program aims to sample 5% of lakes larger than 20 hectares within each 5-year cycle. Half of the lakes selected in the first cycle are designated as fixed sites - to be re-sampled in subsequent cycles. The other half of the sample is a stratified random sample of lakes picked in each cycle (i.e. variable sites). Whereas a fixed site design maximizes power to detect changes, the inclusion of variable sites improves the precision of status reporting. Approximately 600 lakes have been sampled to date. Selected results will be presented that highlight variation in the abundance of popular sport fish (walleye (*Sander vitreus*), lake trout (*Salvelinus namaycush*) and smallmouth bass (*Micropterus dolomieu*)) and fish community structure. Because this program uses a proposed North American gillnet standard for sampling fish communities, its results are potentially comparable to results obtained by other agencies adopting this standard.

Far North Aquatic Science Projects: MNR/NESI Preliminary Investigations under the Far North Information and Knowledge Management (FN-IKM) Initiative.

McGovern, S.
Ontario Ministry of Natural Resources

The Far North Information and Knowledge Management (FN-IKM) program is a proactive effort to provide and improve our best and most current information and knowledge in support of community and broad-based planning in Ontario's Far North area. The information acquired is intended to inform First Nations communities and resource planners interested in both resource management opportunities as well as protection measures.

Knowledge and information pertaining to the aquatic ecosystems within the Far North watersheds is sparse. Most accounts focus on some very specific nodes of interest with the more expansive remaining waterscape relatively unexplored. Our knowledge, for example, on the location, distribution and status of many sensitive species (e.g. Lake Sturgeon) and status on the populations of species important for subsistence use is very poor.

This presentation provides an overview of our preliminary studies and investigations of Far North rivers, aquatic ecosystems and resources particularly important to the resident First Nations communities. We highlight some outcomes of our discussions with First Nations community members and their Tribal Council and their articulation and perceptions of the water, land and pending resource interests. These discussions largely informed and determined the priority for study type and location.

We also provide some examples of our investigations progress to date including: fish community and habitat reconnaissance work in the Albany River, in concert with the Mushkegowuk Environmental Research Center (MERC); developing a GIS-based tool for characterizing river morphology as well as many other physical attributes using remote methods; approaches for acquiring Traditional Ecological Knowledge on Lake Sturgeon (Peawanuck); and finally, a status and trends report which suggests knowledge gap areas to attend to for improved resource protection and planning decisions.

Remote Predictive Mapping of Surficial Materials in the Far North of Ontario

Barnett, P.J. and Yeung, K.H.
Ontario Geological Survey

In 2008, the Ontario government announced plans to permanently protect half of the Far North region of Ontario and launched a planning process to support this goal (Far North Information Knowledge Management Program). During the initial stages of planning the need for primary landscape data became apparent. A project to remotely predict surficial materials was initiated by the Ontario Geological Survey in response to this information need.

SPOT imagery (4 colour bands and the panchromatic band), a digital elevation model and its derivatives and the Ontario Hydro Network vector drainage shape files are the primary data sources for this remote predictive mapping exercise. Multiresolution segmentation algorithm, using different image layer weights, scale parameters and homogeneity criterion, within an object-based image analysis software is used to achieve meaningful objects representing various surficial material types. Objects are then classified based on digital signature, internal variability of signature and proximity to certain vector layers and certain adjacent material types.

Limited helicopter-supported field work combined with the examination of archival information provides the ground control on the classification of objects. In addition, information from the various other Far North Information Knowledge Management Program projects, such as base data and land cover information has been used in the interpretation and classification of the surficial materials.

Field work in 2010 was centered on the community of Fort Severn. Interesting aspects of this area includes several exposures of Sangamon Interglacial sediments that were sampled for pollen and macrofossil analysis and large retrogressive slides of various ages along the banks of the Severn River.

Organic-bearing Sangamon Interglacial sediments along the Beaver River (scale 8 cm).

Determining Soil-Plant Reference Conditions for the Reclamation of Mine Stockpiles in the Hudson Bay Lowland

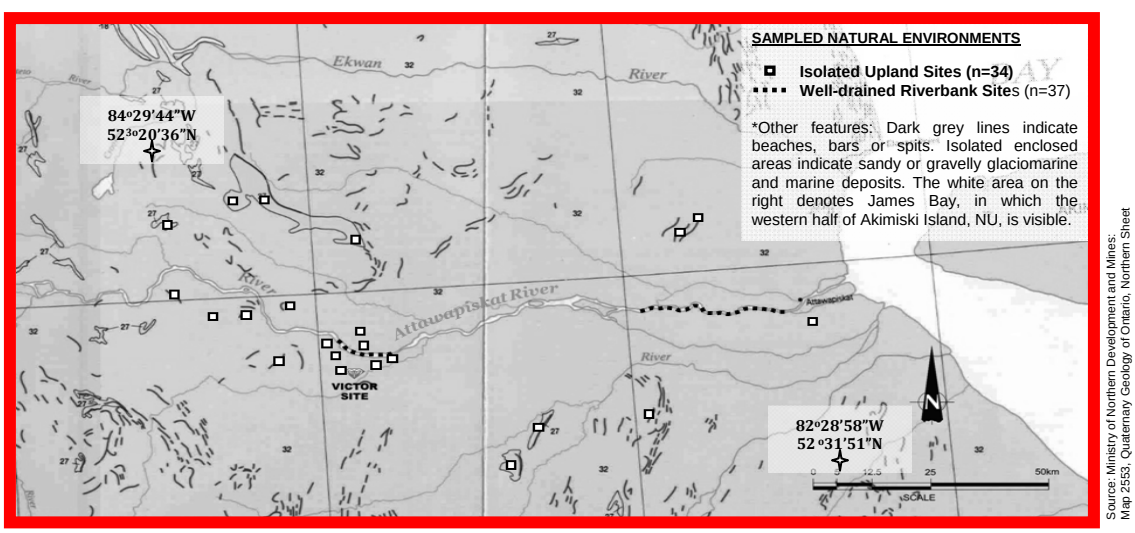
Garrah, K. and Campbell, D.
Laurentian University

At mining operations in the Hudson Bay Lowland of subarctic Canada, processed kimberlites along with other materials are being stockpiled on the landscape. Reclaiming these sites to self-sustaining environments dominated by native plant species requires an understanding of succession and soil-plant relationships on natural upland environments in the region. Currently, little is known about these relationships and associated plant community succession.

Key vegetation and soil characteristics were sampled along a natural successional gradient of well-drained riverbank sites near the De Beers Victor Mine, Ontario, Canada. Isolated natural uplands were similarly examined along a 150km east-west geological chronosequence beginning at James Bay. Methods reflect those of the forest ecosystem classification program in Northern Ontario, in which (i) vegetation in a 10m x 10m plot was described at each site, and (ii) soils were determined by describing a soil pit. Parameters of interest included vegetation structure and cover, species richness and species composition, forest mensuration variables and soil physical and chemical characteristics. Descriptive statistics were calculated for all quantitative variables. Relationships among site types were analysed using principal components, canonical correspondence, and cluster analysis.

The four objectives of this study were to (i) describe the observed plant communities and soil profiles; (ii) group plant communities and soils in successional stages; (iii) describe the mean condition and the range of conditions within measured parameters; and (iv) construct a series of plant and soil reference conditions.

The variability determined in the natural systems will provide parameters for creating regionally compatible novel ecosystems on mine stockpiles. These reference conditions will offer restoration managers a template of possible upland community targets and successional trajectories in similar environments.



Source: Ministry of Northern Development and Mines; Map 2553, Quaternary Geology of Ontario, Northern Sheet

Location of sites at which this study was conducted. Note the dominance of peatlands (light grey) and the scarcity of upland landforms (denoted in the legend) across this entire region.

PosterAbstracts

Science For a Changing North II

** denotes posters entered in the student competition* STUDENT POSTER.
$500 prize sponsored by the Biology Department, Laurentian University.

1. **Babin-Fenske, J.J and Gunn, J.M. ,** (Cooperative Freshwater Ecology Unit, Laurentian University), Reestablishment of Sensitive Amphipods in Lakes Recovering From Acidification and Metal Contamination.

2. **Biastoch*, R.G. and Quinlan, R.** (York University), Comparing Lake Abundance and Surface Area Changes Based on 1957 and 2009 Remotely Sensed Images near Baker Lake, Nunavut.

3. **Boland*, K., and Dirszowsky, R.** (Cooperative Freshwater Ecology Unit, Laurentian University), The Sediment Budget of Daisy Lake: Implications for Landscape Change in a Disturbed Boreal Shield Landscape

4. **Campbell, D. and Bradley, J.** (Laurentian University), Natural Revegetation of Winter Roads on Peatlands in the Hudson Bay Lowland

5. **Corston, A. and Gunn, J.M.** (Cooperative Freshwater Ecology Unit, Laurentian University), The Effects of a Rock Bass (*Ambloplites rupestris*) Introduction on the Native Fish Community of Pedro Lake

6. **Davidson, J.** (Cooperative Freshwater Ecology Unit, Laurentian University), Effects of Vegetation Loss on Stream Invertebrate Diversity and Nickel Concentrations in a Small Urban Industrial Watershed

7. **De Silva*, N.[1], Ryser, P.[1] and Cholewa, E.[2]** ([1]Laurentian University, [2]Nippising University), Influence of Heavy-Metal and Drought on Morphology and Anatomy in Red Maple (*Acer Rubrum*)

8. **Dirszowsky, R.W W.[1], Finkelstein, S.A.[2], and Davis, A.M.[2]** ([1]Cooperative Freshwater Ecology Unit, Laurentian University, [2]University of Toronto), The Pollen Record of Clearwater Lake: Implications for Human Impact and Landcover Change in the Sudbury Area from the Mid-19th Century On

9. **Gillespie, M. and Gunn, J.M.** (Cooperative Freshwater Ecology Unit, Laurentian University), Effects of Experimental Deepening of the Thermocline on Fish Community Biomass and Trophic Ecology

10. **Hargan, K.E.[1], Rühland. K.M.[1], Paterson, A.M.[2], Finkelstein, S.[3] and Smol, J.P[1]** ([1]Queen's University, [2]Ontario Ministry of the Environment, [3]University of Toronto), Diatoms as Indicators of Environmental and Climatic Change in Peatlands of the Hudson Bay Lowlands, Ontario, Canada

11. **Holmquist*, J.R., and MacDonald, G.M.** (University of California, Los Angeles), Peatland Initiation and Long Term Apparent C-accumulation in the Western James Bay Lowlands

PosterAbstracts (continued)

12. **Kirkey*, F.M. and Ryser, P.** (Larentian University), Antagonistic and Additive Responses to Heavy Metals and Drought in Leaves of White Birch (Betula papyrifera)

13. **Kurek, J.[1], Weeber, R.C.[2], and Smol, J.P.[1]** ([1]Queen's University, [2]Canadian Wildlife Service), Crustacean Zooplankton Community Response to Environmental, Predation, and Dispersal-Related Gradients

14. **Luszczek*, C. and Quinlan, R.** (York University), Limnological Controls and Spatial Variation in Littoral Macroinvertebrates Communities across Central and Eastern Nunavut, Canada

15. **Myre*, M.[1], Mykytczuk, N.[2], Leduc, L.[1] and Merritt, T.[1]** ([1]Laurentian University, [2]McGill University), Isolation and Identification of Bacterial Species from an Acid Mine Drainage Site in Copper Cliff, Ontario

16. **Narendrula*, R., Nkongolo, K., and Beckett, P.** (Laurentian University), Comparative Soil Metal Analyses in Sudbury (Canada) and Lubumbashi (DR-Congo): Two Contrasting Mining Cities with a Similar Legacy.

17. **O'Reilly*, B.C. and Finkelstein, S.A.** (University of Toronto), Using Pollen Assemblages to Track Holocene Vegetation Change, Hydroclimatic Variability and Carbon Accumulation at a Fen Site in the Hudson Bay Lowlands

18. **Philips, T. and Watmough, S.(Trent University),** A Nutrient Budget for a Selectively Harvested Forest: Implications for Sustainability?

19. **Kierann R. Santala** (Laurentian University), The Introduction of Native Understory Woodland Species on Reclaimed Mine Lands

20. **Stasko*, A., Gunn, J., and Johnston, T.** (Cooperative Freshwater Ecology Unit, Laurentian University), The Role of DOC in Diet Partitioning Between Walleye (*Sander Vitreus*) and Smallmouth Bass (*Micropterus Dolomieu*) in Boreal Shield Lakes

21. **Symons, C.[1], Arnott, S.[1] & Sweetman, J.[2]** ([1]Queen's University, [2]Parks Canada), Nutrient Limitation and Zooplankton Grazing Control of Phytoplankton Biomass in Subarctic Lakes, Wapusk National Park, Manitoba

22. ***Szkokan-Emilson*, E.[1], Watmough, S.[2], and Gunn, J.[1]***(Cooperative Frshwater Ecology Unit, Laurentian University, [2]Environmental Resource Science, Trent University), Internal Processing of Nutrients and Metals in Wetlands and Associated Fluxes: Importance to Early Successional Aquatic Communities in Recovering Watersheds

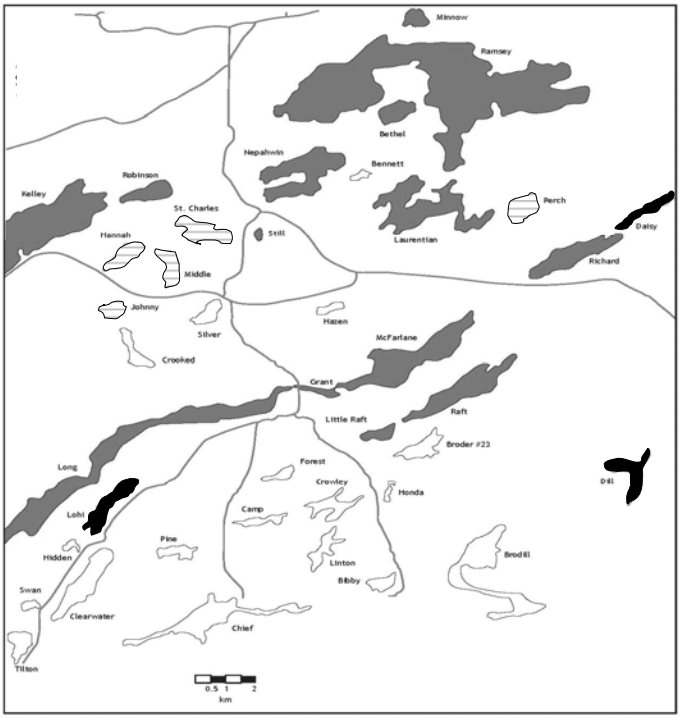
23. **Tang*, R.W.K., Johnston, T.A., Gunn, J.M.** (Cooperative Freshwater Ecology Unit, Laurentian University), Temporal Trends in Mercury Concentrations of Large-Bodied Fishes in Northern Ontario Lakes

24. **Thienpont*, J.[1], Nesbitt, H.[1], Deasley, K.[1], Korosi, J., Kokelj, S.[2], Pisaric, M.[3] and Smol, J.[1] (***[1]*Queen's University,* [2]*Department of Indian and Northern Affairs Canada,* [3]*Carleton University),* Marine Storm Surge Damage to Arctic Freshwater Ecosystems

Reestablishment of Sensitive Amphipods in Lakes Recovering From Acidification and Metal Contamination

Babin-Fenske, J.J and Gunn, J.M.
Cooperative Freshwater Ecology Unit, Laurentian University

Biological recovery in ecosystems degraded by industrial pollution, such as acidification and metal contamination, involves a complex sequence of events. When a source of such pollution has been removed, lingering contamination, physical changes in the habitat or nutrient stress may result in a lag in the reestablishment or reintroduction of otherwise naturally occurring species. The reduction of 90% of SO_2 emissions and the extensive soil liming and other land reclamation efforts in Sudbury, Ontario has resulted in increased pH and decreased metal contamination in both the soils and waters in the region. Subsequently, there has been a recovery of a number of key species in both aquatic and terrestrial habitats. Despite such success, certain aquatic species remain absent in otherwise apparently healthy lakes. The freshwater amphipod *Hyalella* sp. has been slow or unsuccessful in its reestablishment in a number of lakes that appear to have appropriate conditions for their survival. A 2003 survey demonstrated that lakes are slowly becoming colonized with *Hyalella*. After surveying 14 lakes that were void of *Hyalella* in 2003, we found it had colonized three more lakes in the past seven years while over ten remaining lakes still lack *Hyalella*. This ongoing study will continue monitoring the recolonization of *Hyalella* in the lakes of Sudbury and will provide preliminary attempts to understand the niche requirements of this sensitive amphipod.



Map of *Hyalella* distribution in Sudbury, Ontario. Grey lakes represent lakes containing *Hyalella* in 1990 and 1991, stripes represent newly colonized lakes from the 2003 survey and black represents newly colonized lakes from the 2010 survey.

Comparing Lake Abundance and Surface Area Changes Based on 1957 and 2009 Remotely Sensed Images near Baker Lake, Nunavut

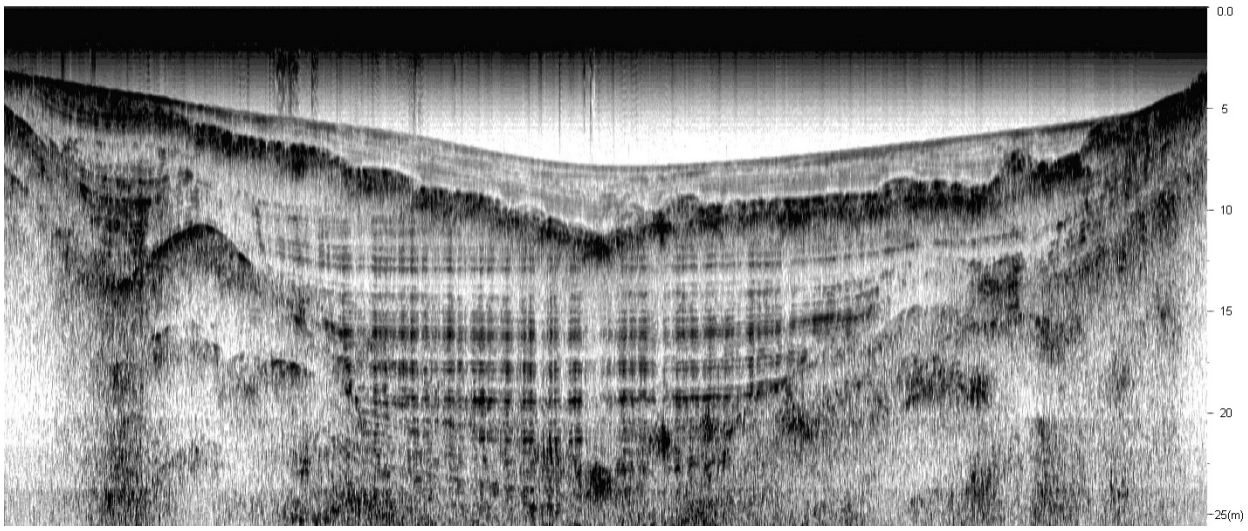
Biastoch, R.G. and Quinlan, R.*
York University

The Canadian Arctic has experienced a changing climate during the 20th century, and these changes in Arctic aquatic ecosystems are becoming apparent at large geographical scales. For example, recent studies using remote sensing imagery have revealed changes in Arctic lake abundance and surface area over the last 60 years. To-date there has been no intensive remote sensing analysis of surface waters in the Kivalliq Region of Nunavut, Canada. In July 2009, 21 lakes outside of Baker Lake, NU, were mapped using a handheld GPS unit. Remotely sensed images from July 1957 (aerial photography) and June 2009 (Landsat 7 Enhanced Thematic Mapper Plus) were processed to obtain lake abundance and surface areas. The Landsat mid infrared (MIR) or band 5, which exhibits high absorption by water and high reflectance by vegetation, strongly contrasts between land and water. Histogram thresholding was performed on the MIR to separate land and water creating a binary raster file, and this raster was converted to a polygon file within a GIS for further processing. My first research objective is to compare the difference between GPS derived lake surface areas and surface areas obtained from satellite imagery; while it is expected that the coarse pixel resolution of the satellite imagery will result in different surface areas than the GPS surface areas, it is unclear in what direction this difference may occur (positive or negative). My second objective is to compare lake abundance and surface area calculations from the 1957 aerial photography and the 2009 satellite imagery. By contrasting the two temporal datasets I intend to determine how lake surface areas and/or lake abundance have changed over the 52 year period during a period of warming climate.

The Sediment Budget of Daisy Lake: Implications for Landscape Change in a Disturbed Boreal Shield Landscape

Boland, K., and Dirszowsky, R.*
Cooperative Freshwater Ecology Unit, Laurentian University

Human settlement and industrial activity over the past 150 years has resulted in significant land cover change and erosion of soils in the Sudbury region. While this effect is readily apparent on the barren rocky uplands of the area, little data exists detailing the rate, extent and pattern of sediment reworking on the landscape. This work examines that component of regional sediment budgets associated with lake basin infilling of eroded surface sediment, using Daisy Lake (4 km SE of Coniston) as an example. Field work consisted of sub-bottom acoustic imaging supplemented by piston coring at three sites (9 cores) within the lake and extensive surface sediment grab samples (n = 230). Cores (4 cm diameter) recovered ranged from 55 cm to 133 cm in length, with most material being organic rich (15% to 40%) and having low bulk density ($0.3 g/cm^3$ to $1.4 g/cm^3$), decreasing and increasing respectively with core depth. In two cores (uplake), coarse bedded, minerogenic, silty clays were encountered, likely of late Pleistocene (deglacial) origin. Sub-bottom acoustic profiles (12 km total) revealed a comparatively thick basin fill (up to 25 m) with 2-3 distinct facies visible. An upper relatively homogenous layer (1m to 6m) corresponds to Holocene and recently deposited materials. Distinct thicker lobate masses are occasionally noted in near-shore areas. The underlying unit (up to 20 m) exhibits acoustically stratified signature characteristic of late Pleistocene glaciolacustrine sediments. Overall the sediment, mapped through direct sampling imaging, does not appear to account for the landscape losses noted above, thus pointing towards other sites of deposition within the catchment.

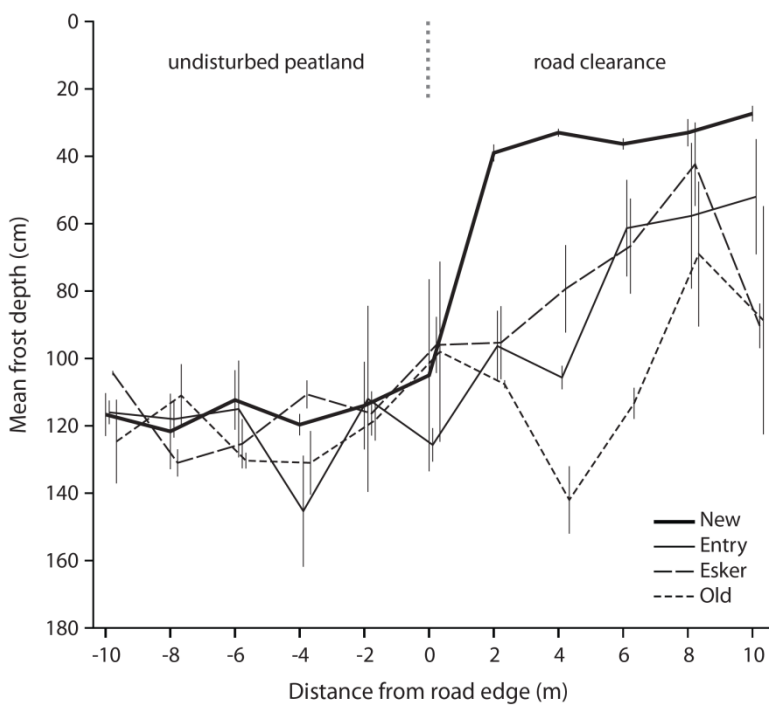


140m (mid-lake) sub-bottom acoustic profile of Daisy Lake, depicting 2 distinct facies.

Natural Revegetation of Winter Roads on Peatlands in the Hudson Bay Lowland

Campbell, D. and Bradley, J.
Laurentian University

Winter roads across peatlands are increasingly being used to access remote communities and resource development camps, yet relatively little is known on their ability to recover after abandonment. In this study, we examined winter roads abandoned within five years in the Hudson Bay Lowland to determine their extent of natural recovery and the need for active restoration practices. We sampled five winter roads of increasing age of abandonment and compared surface elevation, microtopography, active layer depth, species richness, evenness and composition between winter road clearances and adjacent undisturbed peatland. No difference in surface elevation and hummock-hollow microtopography was detected between road clearances and adjacent peatlands, but clearances had significantly thinner active layer, which persisted at least five years after abandonment. On roads abandoned within 4-5 years, the cover of lichens, bryophytes, and vascular plants returned to similar levels as in undisturbed peatlands, although species richness per quadrat remained lower. Multivariate analyses indicated that composition of species was also different but did not depend on the road. The limited recovery of black spruce on these peatlands and their slow growth indicates that the full recovery of vegetation structure on these road clearances could take decades. Natural revegetation could be augmented with active restoration protocols, specifically the planting of black spruce to return vegetation structure, and possibly the restoration of a *Sphagnum* carpet.

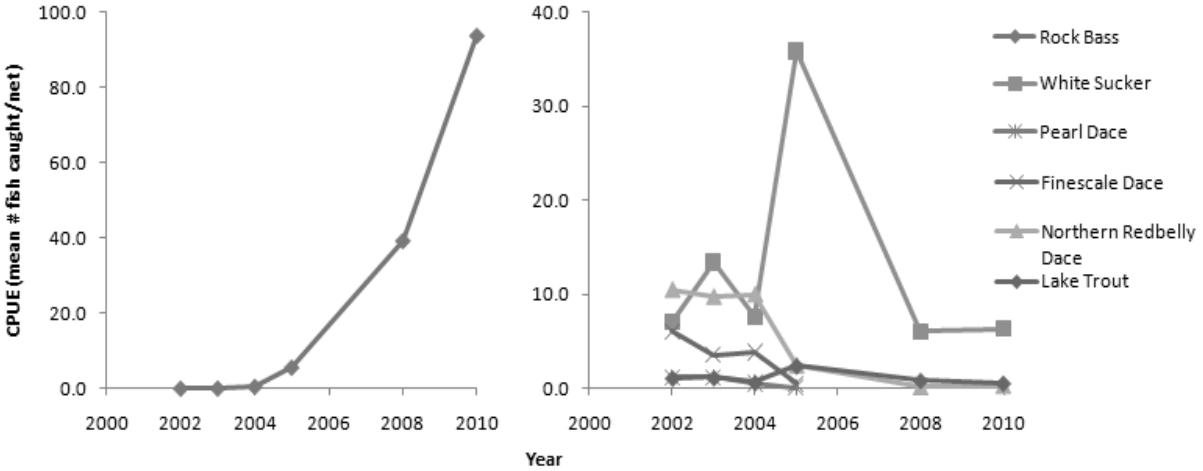


Changes in frost depth for four roads sampled in mid-August 2010 (mean ± SE; n=3).

The Effects of a Rock Bass (*Ambloplites rupestris*) Introduction on the Native Fish Community of Pedro Lake

Corston, A. and Gunn, J.M.
Cooperative Freshwater Ecology Unit, Laurentian University

Rock bass (*Ambloplites rupestris*) are a widely introduced species in Ontario waters. Their presence in Pedro Lake, near Sudbury, Ontario, was first recorded in 2002 during a NORDIC Index Netting survey. This was a particularly worrisome development because Pedro Lake is a small (63.9 ha), shallow (11.3 m max depth) lake containing lake trout (*Salvelinus namaycush*), leaving little opportunity for spatial separation among competitors. Pedro Lake is isothermal and thus lacks a prominent summer hypolimnion. Since the introduction of rock bass, changes in the fish community have occurred, mainly a reduction in the abundance of small prey fish such as northern redbelly dace (*Chrosomus eos*) and finescale dace (*Chrosomus neogaeus*). Also, the lake trout population has shown a decrease in average weight after the rock bass population had become established. Past research has shown that the trophic positions of lake trout were lower in bass-invaded lakes than those where no bass were present. Dietary changes of lake trout from fish to zooplankton were also observed in bass-invaded lakes, resulting in slower growth rates and shorter life spans. Recommendations for further research have been made, including stomach content and stable isotope analysis in lake trout and rock bass in order to acquire a better understanding of the effects of the rock bass invasion in Pedro Lake. An increased understanding of rock bass-lake trout interactions may lead to implications for fisheries management in areas where non-native fish species are often deliberately introduced into water bodies.



Mean catch per unit of effort (CPUE) of fish species captured in Pedro Lake, Sudbury from 2002 to 2010 showing changes in native fish community (right) as a result of increasing abundance of invasive rock bass (*Ambloplites rupestris*; left).

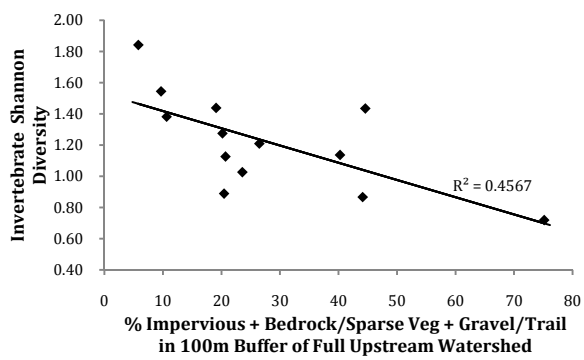
Effects of Vegetation Loss on Stream Invertebrate Diversity and Nickel Concentrations in a Small Urban Industrial Watershed

Davidson, J.
Cooperative Freshwater Ecology Unit, Laurentian University

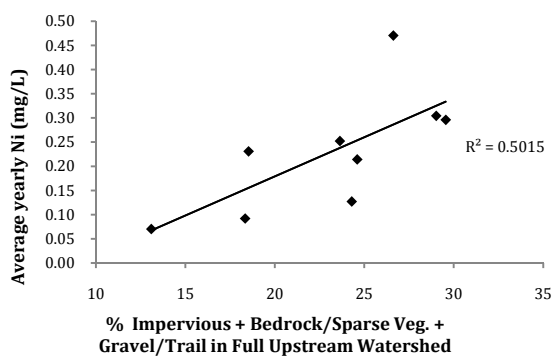
Land cover in the watershed of Junction Creek that flows through the industrial city of Sudbury, Canada, the site of one of the largest metal (Cu, Ni) mining complexes on earth, has undergone considerable change in the past 100 years, from boreal forest to industrial barren to a partially restored mixed forest landscape.

Today, large areas of the 93 km^2 watershed consist of exposed bedrock interspersed with reforested tracts in varying stages of recovery, as well as urban development, and residential neighbourhoods. The 23km creek is fed by 3 tributaries, and apart from a 1 km culvert under the city core, the system runs a comparatively natural course and supports recovering populations of fish and invertebrates. Watershed land cover was initially classified into 17 categories by hand-digitizing orthographic photos in ArcMap (ESRI 2009). Benthic invertebrates from 13 sites were sampled using rapid bioassesssment techniques, following Environment Canada's CABIN protocols. Shannon Diversity and average yearly heavy metal concentrations at each site were then correlated with % land cover types at 4 watershed scales, expanding up from measures of 100m buffer strips to the full upstream drainage area. Diversity at test sites was also put in the context of a large database of non-impacted regional reference sites. Reference sites were matched to each test site using physical habitat PCA space; 7 non-anthropogenically influenced habitat variables determined each test sites' 15 nearest neighbours, from which a mean reference diversity could be calculated.

Benthic invertebrate diversity decreased significantly with the amount (%) of unforested or impervious surface area in the drainage area. These relationships existed at all 4 watershed scales, but were most significant when human-made surfaces (roads, roofs, parking lots) were combined with exposed bedrock and gravel into a single cover class (Figure 1; Pearson correlation= -0.771, p=.002). In addition, Ni concentrations were significantly correlated with the total impervious surface (urban development plus historically devegetated bedrock) in the full upstream watershed (Figure 2); all mean Ni concentrations were well above the Ontario water quality objective of 0.025 mg/L. The cumulative effects of altered landscapes were clearly demonstrated by these simple measures of benthic community health and average metal concentration.



Diversity for 13 sites in Junction Creek is negatively correlated with total impervious surface in the near riparian watershed.



Average yearly Nickel concentration is positively correlated with total impervious surface in the test sites' full watershed.

Influence of Heavy-Metal and Drought on Morphology and Anatomy in Red Maple (*Acer Rubrum*)

De Silva, N.* [1], *Ryser, P.*[1] *and Cholewa, E.* [2]
[1]*Laurentian University,* [2]*Nippising University*

Soil contamination is one of the crucial environmental issues in mining industry. Heavy-metal contaminated soils often have poor structure with low water-holding capacity. Thus reclamation activities of heavy metal contaminated soils are often hampered by drought stress. The hypothesis in this study was that heavy metals in soil aggravate drought effect in red maple by influencing the structural and morphological plant traits related to water acquisition and transportation. In an outdoor pot experiment, red maple seedlings were exposed to two levels of heavy-metals and two levels of water in a factorial combination. Metal contamination was achieved by mixing 1.5% Cu-Ni containing slag with sand (pH 5.5) and pure sand serving as control. The two levels of soil moisture were 10% and 25% gravimetric water content. The 10% represent dry moisture content and 25% close to the field capacity as the control moisture level. In the experiment, both heavy-metals and drought had similar effects on measured size related plant traits. Both stresses reduced leaf area, stem length and the length of the longest root length. Xylem cross sectional area was reduced, both absolutely and relatively. The magnitude of the effects was similar for both stresses and the effect of the combined stresses was additive. Specific leaf area and leaf dry matter content were not influenced by either of the stresses. The results supported the hypothesis that heavy-metal stress adversely influences morphological and structural size related plant traits potentially important for plant water status. Reduction in root length and xylem vessel area gives rise to poor water acquisition and transportation capacity respectively. However, the reduced leaf area is bound to reduce transpiration.

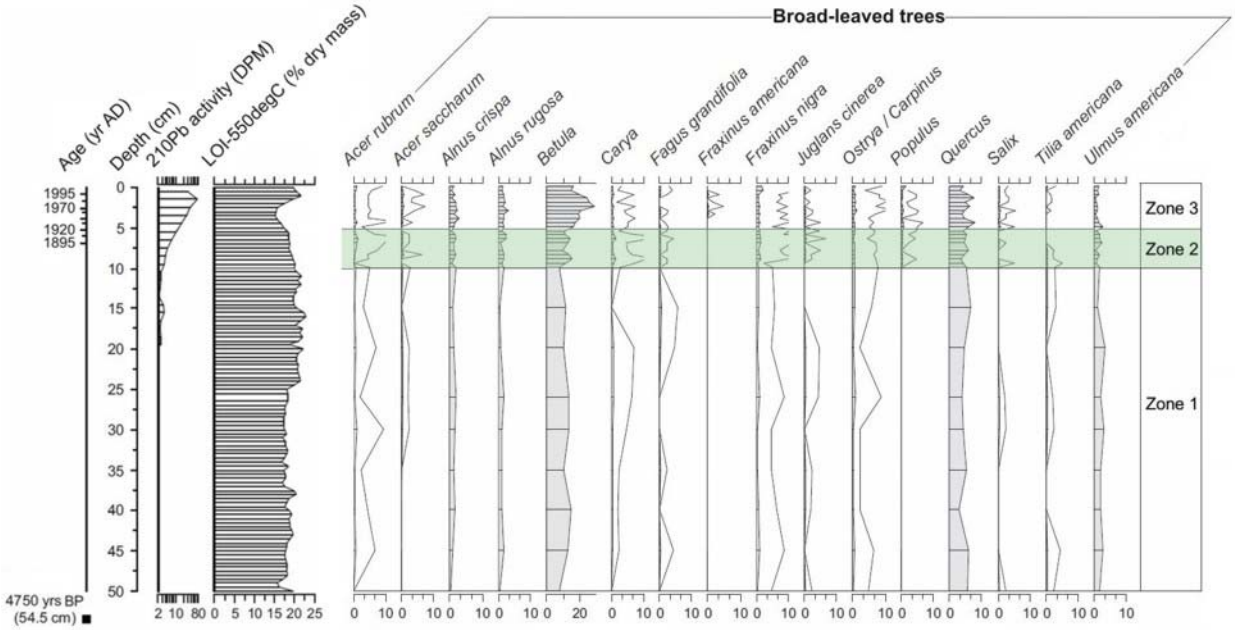
Average values and ANOVA p values for measured plant variables.

Variable	Average values				ANOVA p values		
	Control Wet	Control Dry	Metal Wet	Metal Dry	Metal	Drought	Metal × Drought
Total leaf area (cm^2)	57	34	39	22	0.019	0.003	0.603
Longest root length (cm)	17.0	10.0	13.6	7.0	0.056	0.000	0.952
Stem length (cm)	8.9	5.0	5.8	3.3	0.010	0.000	0.359
Stem total cross sec. area (mm^2)	1.93	1.21	1.15	0.86	0.002	0.003	0.568
Stem xylem cross sec. area (mm^2)	1.12	0.51	0.50	0.31	0.001	0.001	0.601
Stem xylem relative area (%)	51.7	39.7	41.2	33.2	0.003	0.001	0.471
Root xylem cross sec. area (mm^2)	1.71	0.78	0.86	0.55	0.002	0.001	0.418

The Pollen Record of Clearwater Lake: Implications for Human Impact and Landcover Change in the Sudbury Area from the Mid-19th Century On

Dirszowsky, R.W.[1], Finkelstein, S.A.[2], and Davis, A.M.[2]
[1]Cooperative Freshwater Ecology Unit, Laurentian University, [2]University of Toronto

It is well known that aquatic and terrestrial ecosystems in the Sudbury area have been damaged by environmental pollution and associated stresses (lumbering, fire, etc.) related to regional mining activities and human settlement. At the same time comparisons of 19th century surveys and modern forest inventories indicate that shade-intolerant deciduous trees have partially replaced boreal conifers in the ecotonal region. Few long-term data are available to directly understand the cause of increased deciduousness of the forests of central Ontario. Paleoenvironmental records provide evidence of long-term ecological change, and allow comparisons between recent anthropogenic changes and natural variability. A late Holocene ^{210}Pb-dated pollen record from oligotrophic Clearwater Lake near Sudbury, Ontario reveals vegetation changes that began around 1870 AD, coincident with the beginnings of timber extraction. Whereas the earliest recorded vegetation changes pre-date atmospheric pollution associated with mining activities, further changes recorded after 1920 AD are linked to increased smelter activity and chimney installation, and coincide temporally with major shifts in the aquatic ecology of Clearwater Lake. The pollen data indicate that the 20th century increase in deciduous trees is not limited to *Betula* and *Populus*, but includes other taxa. Along with an increase in diversity of local pollen types, recent changes in the composition of local forests are in strong contrast to the relatively consistent pollen assemblages of the pre-industrial late Holocene.

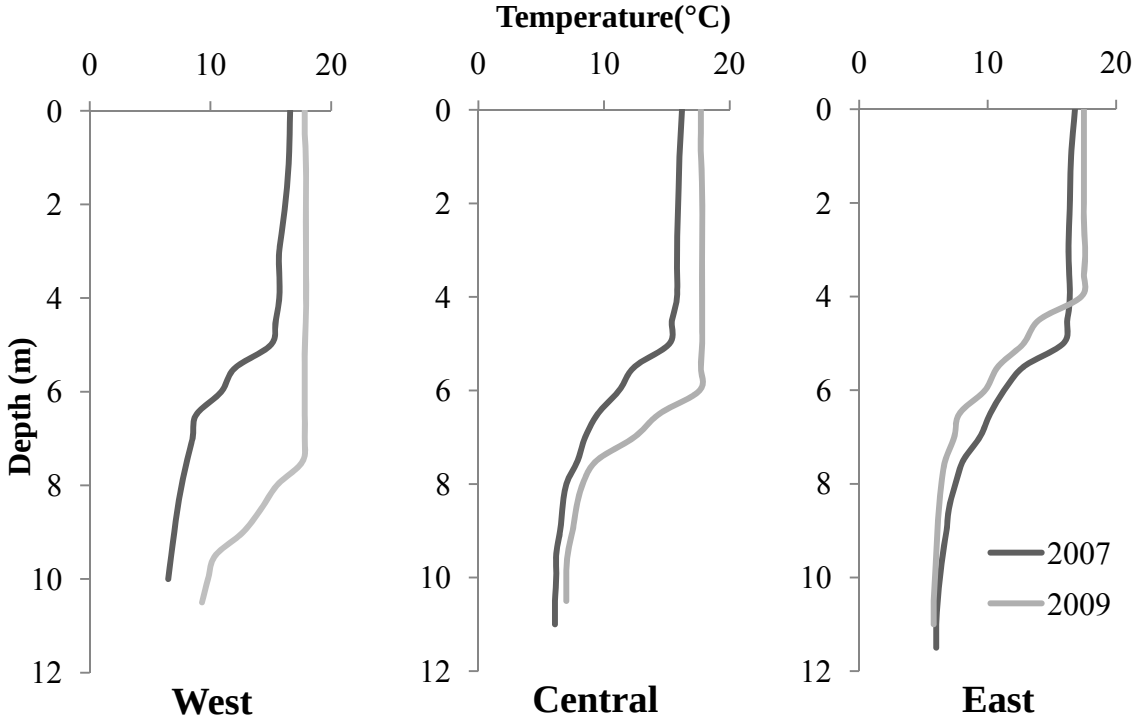


Age-depth relationship, organic matter content and deciduous pollen assemblage for Clearwater Lake sediments.

Effects of Experimental Deepening of the Thermocline on Fish Community Biomass and Trophic Ecology

Gillespie, M. and Gunn, J.M.
Cooperative Freshwater Ecology Unit, Laurentian University

A SolarBee® lake mixer was used to deepen the thermocline (from 4 to 7m) in one basin of a small (18ha) three basin lake (Lac Croche) to test the effects associated with changing wind speed and other climate factors on fish habitat use and trophic interactions. The experimental lake has a small reproducing lake trout (*Salvelinus namaycush*) population even though the hypolimnion was anoxic (DO <1ppm below 5m) throughout much of the year. However the fish community was dominated by creek chub (*Semolitus atromaculatus*), brown bullhead (*Ameiurus nebulosus*) and white suckers (*Catostomus commersonii*). After installation of the mixer in 2008 the thermocline set up at 4, 6 and 7.5m across the 3 basins. In 2009 a depth stratified sampling procedure (Nordic Index Netting) was used to assess effects on the fish populations. The community fish abundance increased with thermocline depth and the decreased zones of anoxia. Changes in creek chub abundance were responsible for the significant increase in fish abundance in the basin with the deepest theromcline. Stable isotope ($\delta^{13}C$, $\delta^{15}N$) analysis showed that brown bullhead exhibited changes in trophic niche dimensions represented by depletion of $\delta^{13}C$. However $\delta^{15}N$ signature suggested that the depletion in $\delta^{13}C$ maybe related to change in the quality of food through changes in associated microbial population rather then significant changes in their choice of diet.



Water temperature (°C) pre manipulation (2007) and post manipulation (2009) of each treatment basin (treatment 1: west +3.5m, treatment 2: central +2m and treatment 3: east control) in Lac Croche Québec.

Diatoms as Indicators of Environmental and Climatic Change in Peatlands of the Hudson Bay Lowlands, Ontario, Canada

Hargan, K.E.[1], Rühland. K.M.[1], Paterson, A.M.[2], Finkelstein, S.[3] and Smol, J.P[1]
[1]Queen's University, [2]Ontario Ministry of the Environment, [3]University of Toronto

The Hudson Bay Lowlands contain one of the largest wetland complexes in the world that contributes significantly to the global carbon cycle. Peatlands (organic wetlands) preserve a variety of biotic indicators that can provide insights into the timing and nature of long-term climatic and environmental change. Diatoms (siliceous algae) are sensitive to many peatland microhabitat conditions including macro-vegetation type, pH, position relative to the water table, nutrients, and therefore have potential to track historical peatland changes. However, comprehensive studies of diatom assemblages from peatland systems are scarce, particularly in northern latitudes, resulting in poorly known taxonomy and autecology of the peatland diatoms. Exploring the distribution of diatom taxa across a variety of peatland types will increase our understanding of the changing north, particularly when used in tandem with other commonly used indicators.

The objectives of our study include 1) to conduct a spatial survey of diatom taxa from surface peat samples and environmental data from a broad range of peatland habitat types and gradients including vegetation type (e.g., rich fen, poor fen, bog), chemical (e.g., pH, mineral), and climatic gradients (e.g., water table depth, degree of permafrost); and 2) to explore the diatom assemblage compositional changes in a Holocene peat core from the same region.

A suite of 33 surface peat samples, collected in the Attawapiskat River watershed (52°71'-52°85' N, 83°92'-84°17' W) have been examined for diatoms and other siliceous microfossils (e.g., phytoliths, chrysophyte cysts, protozoan plates). In 28 of these surface samples, diatom abundance in ~0.3 g of peat was adequate (300 to 500 diatom valves) to establish reliable counts for paleolimnological analyses. Additionally, diatoms will be examined from a 319 cm-long core taken in a peat bog in the same region of the surface peat samples, which spans the past ca. 6000 yrs. Changes in diatom assemblage composition may provide important insights into the timing of peat initiation in the HBL and may track the developmental history of this peatland. Future work includes the development of diatom-based inference models generated from the surface peat samples that could potentially be applied to the Holocene diatom record. Our diatom data will be compared to other biological proxies analyzed in the same samples, including testate amoebae and pollen.

Peatland Initiation and Long Term Apparent C-accumulation in the Western James Bay Lowlands

Holmquist, J.R., and MacDonald, G.M.*
University of California, Los Angeles

Peatlands have acted as a net sink of CO_2 over the Holocene and currently sequester 1/3 of the world's global soil carbon (C) in only 2-3 percent of its surface (Gorham E., 1991, Ecological Applications, v 1, p. 182-195). Disproportionate warming in the North has the potential to enhance or reverse this C sink depending on how warming affects the balance between peat decay and peat production (Dise, N.B., 2009, Science, v. 326, p. 820-826). Records of climate and long term apparent rates of C accumulation (LARCA) are preserved in peat, and have become important for framing natural experiments by using natural gradients, such as latitude, and paleoclimatic changes inferred from proxy records, to determine major drivers of peat formation and C sequestration rates (Loisel, J. and M. Garneau, 2010, Palaeogeography, Palaeoclimatology, Palaeoecology, v. 291, p. 493-533; Beilman, et al., 2009, Biogeochemical Cycles, v. 23,p. 1-12). The central Hudson and James Bay Lowlands have been particularly underrepresented in the paleorecord until the recent acquisition of a North-South transect of 10 cores spanning the lowlands between Thunder Bay, ON and Churchill, MN. Basal dates range from 800 cal ybp (calendar years before present) to ~8 ka cal ybp. Basal dates agree with deglaciation models, but show evidence of delayed peat formation. Low-resolution calculations of the LARCA range from (14-41 g m^{-2} yr^{-1}). These values are consistent with other northern peatlands. LARCA negatively correlates with latitude making it likely that peat age, temperature isotherms, or both have an effect on LARCA in the James Bay Lowlands. Future developments for this study involve creating 400 year resolved chronologies for the last 2 ka ybp, and millennially resolved chronologies for core portions older than 2 ka ybp. Variations in past hydrology and temperature will be reconstructed by using proxies to examine how climatic changes may have influenced rates of C-accumulation over the Holocene

Antagonistic and Additive Responses to Heavy Metals and Drought in Leaves of White Birch (*Betula papyrifera*)

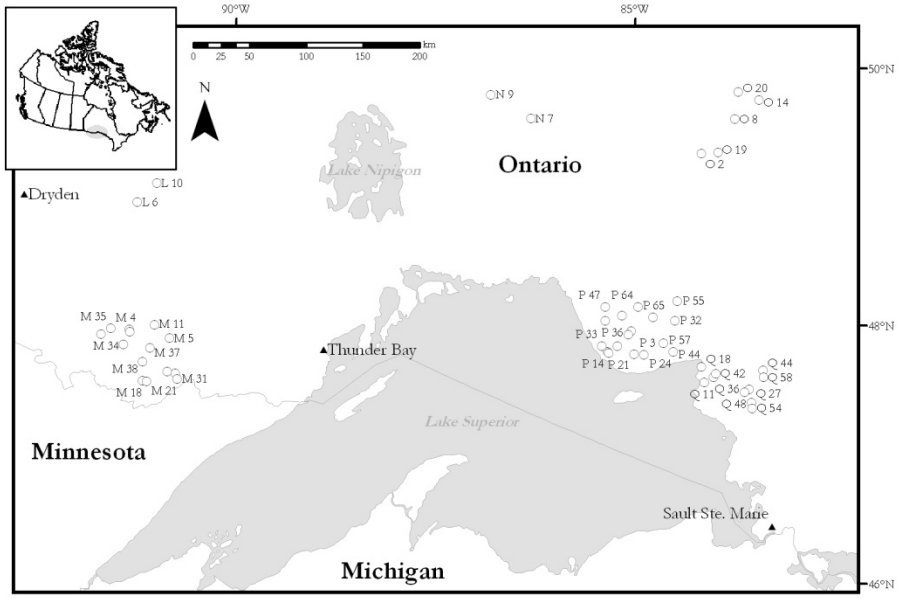
Kirkey, F.M. and Ryser, P.*
Laurentian University

Restoration efforts of metal-contaminated soils have to acknowledge that plants live with multiple stressors simultaneously. We investigated the effects of heavy metal contamination on the effect of drought on white birch (*Betula payrifera*). A growth analysis with white birch (a native tree species commonly found on metal-contaminated soils, however with atypical growth forms, indicating signs of stress) was conducted with reciprocal interactions between metal contamination and drought stress, tested in a greenhouse pot experiment over a two month growth period. The freshly germinated seedlings were transplanted into pure sand (control) or sand-2% slag mixture (plant available in solution: 0.29 ppm Cu; 1.4 ppm Ni) with either 35% (field capacity) or 10% (drought) volumetric soil moisture. Both stressors decreased the overall growth of the plants and most measured traits. In general, the effects of metal and drought stress were additive. An exception was leaf lamina thickness, for which the effects of the stresses were antagonistic, combination of both stresses reducing the effect of each of them alone. Both metals and drought reduced Leaf Relative Water Content (LRWC) when applied alone, suggesting reduced water acquisition capacity. Under dry conditions metal contamination resulted in a higher LRWC, suggesting a reduced water loss. This indicates that interactions between metal and drought stresses are more complex than expected.

Crustacean Zooplankton Community Response to Environmental, Predation, and Dispersal-Related Gradients

Kurek, J.[1], Weeber, R.C.[2], and Smol, J.P.[1]
[1]Queen's University, [2]Canadian Wildlife Service

Understanding local and regional controls on communities is a major theme in ecology. Are communities determined primarily by local environmental gradients, biotic interactions, and/or dispersal processes? To address this, remains of crustacean zooplankton (i.e., Cladocera) were examined from the surface sediments of 50 remote Boreal Shield lakes in northwestern Ontario, Canada, to examine three ecologically-relevant explanatory categories. Variation partitioning analyses were used to test and quantify the unique and shared effects of local abiotic measures, predation factors, and spatial variables as predictors of community composition. Thirty-nine taxa were identified and communities were typically composed of pelagic taxa, such as *Bosmina*, daphniids, and *Holopedium gibberum*. Environmental variables (i.e., pH, lake surface area, specific conductivity, and lakewater total aluminum concentration) explained uniquely 8.8% of the variation, which was 2.5 times greater than the unique contributions of predation or dispersal-related spatial variables. Predation and dispersal processes assumed much less of a role in structuring communities. Considering the extensive geographic scale of this study, our paleolimnological approach indicates that broad-scale dispersal limitation of cladocerans seems negligible for the many taxa examined here. Our findings further support the utility of crustacean zooplankton as key biological indicators to track environmental changes within Boreal Shield lakes.



Location of study lakes coded by region (i.e., Sioux Lookout =L, Quetico Provincial Park =M, Nakina =N, Hearst =O, Pukaskwa National Park =P, and Lake Superior Provincial Park =Q).

Limnological Controls and Spatial Variation in Littoral Macroinvertebrates Communities across Central and Eastern Nunavut, Canada

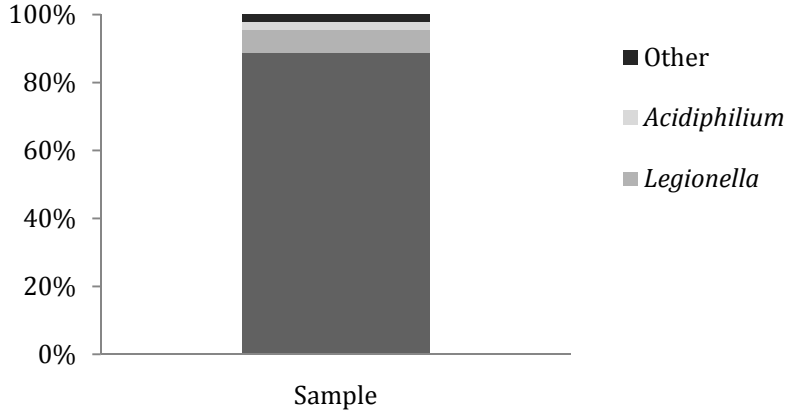
Luszczek, C. and Quinlan, R.*
York University

Ecosystem structure and functioning in Arctic ecosystems is expected to change under the influence of anthropogenically-induced climate change and other human impacts. An assessment of benthic macroinvertebrates in lakes and ponds across Nunavut, Canada was undertaken to determine the current composition, diversity and natural geographic variation among these ecosystems. Over three years, zoobenthos were collected from approximately 85 lakes in Nunavut located near Repulse Bay, Arviat, Rankin Inlet, Baker Lake, Iqaluit, and Clyde River. In addition, substrate characteristics were noted and water samples were collected for major ion chemistry measurements. Organisms collected have been identified to the Family level and multivariate correspondence analysis was performed to determine which environmental variables are responsible for influencing species distributions. Patterns in biodiversity, abundance and community composition were assessed using two-way indicator species analysis (TWINSPAN) and selected biomonitoring indices. Overall, communities were dominated by non-biting midges (Diptera: Chironomidae). 'Scuds' (Amphipoda: Gammaridae) comprised the second-most dominant group, outnumbering the chironomids in lakes near Iqaluit and Rankin Inlet. Diversity was expected to change along a climate gradient (latitude), however differences were also observed between the mainland Kivalliq and Baffin Island regions. Species of the tadpole shrimp (Notostraca: Triopsidae) were found only in Rankin Inlet while the phantom midge (Diptera: Chaoboridae) was observed exclusively in lakes surrounding Iqaluit and appeared to have spread over successive years. Benthic invertebrates form an important part of Arctic aquatic food webs and detailed knowledge of their biogeography and ecology is required for the purposes of biomonitoring, environmental assessment, and predicting anthropogenically-induced aquatic changes to food webs.

Isolation and Identification of Bacterial Species from an Acid Mine Drainage Site in Copper Cliff, Ontario

Myre, M.[1], Mykytczuk, N.[2], Leduc, L.[1] and Merritt, T.[1]*
[1]Laurentian University, [2]McGill University

Acid mine drainage (AMD) is produced by the chemical and microbial oxidation of sulphide mineral waste rock, a by-product of the mining industry. It is detrimental to the surrounding biota due to its acidity, metal toxicity, salinity and ferric iron precipitation. Despite the extreme conditions, some microbial species have adapted to this environment and play an important role in mineral (primarily pyrite, FeS_2) dissolution and acidification. The purpose of this study was to identify the species present in a water sample collected from the Copper Cliff Tailings Area, an environment affected by AMD. We are using a combination of classical microbiology and modern/deep sequencing to identify all the bacterial species present and the fraction of these that could be cultured. For culturing, water samples were inoculated onto three types of solid selective media (FeTSB, ISP and WAYE) and a fragment of the 16S rRNA gene amplified and sequenced to identify individual species matching known organisms in the NCBI database. We are also using direct DNA sequencing to identify all bacterial species present in replicates of these water samples. Total DNA was extracted from these samples and a fragment of the 16S rRNA gene sequenced using pyrosequencing. We have identified seventeen isolates from the solid media cultures. From the pyrosequencing, we have identified 3 dominant genera, *Acidithiobacillus*, *Legionella*, and *Acidiphilium*. *Acidithiobacillus* accounts for 88 to 90% of these sequences including *At. ferrooxidans* and *At. ferrivorans* species. Preliminary analysis suggest that some of the species cultured are present, but very rare (less than 1% of the sequence reads) in the direct sequencing analysis. The identification of the bacterial species in this AMD site is a first step towards understanding the genetic potential of this microbial community. This work will provide a reference for the use of new deep sequencing techniques for the mining industry which will help guide new bioremediation of bioleaching strategies.

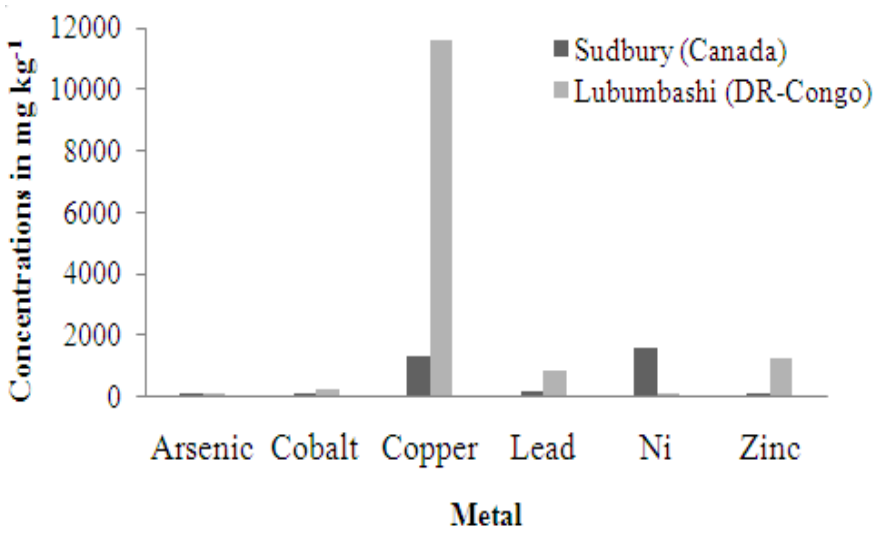


The percent composition of dominant genera accounting for > 1% of over 5000 unique sequence reads in Copper Cliff AMD samples.

Comparative Soil Metal Analyses in Sudbury (Canada) and Lubumbashi (DR-Congo): Two Contrasting Mining Cities with a Similar Legacy.

Narendrula, R., Nkongolo, K., and Beckett, P.*
Laurentian University

DR-Congo is a main producer of copper (Cu) and cobalt (Co) with 6% and 40 % of world production, respectively in 1980. Several hydrometallurgical plants and smelters also produced zinc, arsenic, and cadmium as by-products. In the main mining city of Lubumbashi (DR-Congo), there are virtually no controls on the discharge of pollutants from mining and smelters. The situation is different in Sudbury (Canada) where the production of nickel, copper and other metals has been maintained at high levels while industrial SO_2 emissions have been reduced by approximately 90% through combination of industrial technological developments and legislated controls. In the present study, the levels of copper and cobalt in soils from mining sites in the Lubumbashi were up to 200 fold higher compared to contaminated Sudbury sites and tailings. Zinc content in soil samples from some mining areas in Lubumbashi was at least 70 times higher compared to samples from the Greater Sudbury area. Arsenic content was twice as high in some sites in Greater Lubumbashi compared to the most contaminated site from Sudbury. Lead level in soil samples from Lubumbashi was four times higher than the highest value detected in Sudbury. These two metals (As and Pb) are among the six most damaging toxic pollutants in the World. Nickel content in soil samples from Greater Lubumbashi were much lower compared to Greater Sudbury Region samples. Overall, this study confirms that the African Copper belt region is among the ten most polluted areas in the world.



Metal content in soil samples from the Sudbury (Canada) and Lubumbashi (DR-Congo) sites.

Using Pollen Assemblages to Track Holocene Vegetation Change, Hydroclimatic Variability and Carbon Accumulation at a Fen Site in the Hudson Bay Lowlands

O'Reilly, B.C. and Finkelstein, S.A.*
University of Toronto

Paleoecological records from the Hudson Bay Lowlands are critically important to understand how hydroclimatic variability impacts long-term carbon storage and vegetation community dynamics in this flagship peatland. Complete cores through the peat sequence and into the marine sediment contact (post-glacial Tyrrell Sea transgression) were collected from a fen in the Attawapiskat River watershed (52.7°N, 84.2°W) of the Far North of Ontario in July 2009. The core spans more than 6400 years. A chronology of six AMS radiocarbon dates (conducted on terrestrial material) suggests that peat accumulation has been variable since initiation began at the site, with the highest rates of accumulation (0.124 mm year^{-1}) occurring between 5800 and 2800 years ago. Pollen concentrations range between 19,100 grains ml^{-1} and 155,700 grains ml^{-1}. Pollen analysis indicates that the fen began as a post-glacial salt marsh, dominated by Cattail (*Typha latifolia*) and Sedges (*Cyperaceae*). The dominant vegetation community changes at approximately 6200 years ago to a community centred on Black Spruce (*Picea mariana*), Peat Moss (*Sphagnum sp.*), Jack Pine (*Pinus banksiana*), Birch (*Betula sp.*) and Speckled Alder (*Alnus rugosa*). Rarer pollen types in the sequence include Willow (*Salix sp.*), Goosefoot (*Chenopodium sp.*) and the Heath family (*Ericaceae*). Peat humification levels were assessed at high resolution (approx. every 80 years) via spectrophotometric absorbance at 540 nm following digestion in 8% NaOH. Absorbance increases by approximately 30% with depth in the first 0.5 m (900 years ago to present) (indicating an increasing amount of humic acids and thus greater decomposition). Absorbance then varies by more than 20% in the lower 1.85 m of the core (6200 to 900 years ago), in response to changing moisture conditions in the fen, controlled mainly by depth of the water table and local to regional hydrology.

A Nutrient Budget for a Selectively Harvested Forest: Implications for Sustainability?

Philips, T. and Watmough, S.
Trent University

Decades of acid deposition have reportedly depleted soil base cation reserves with profound implications for surface water Ca concentrations. The long-term impact of soil acidification combined with timber harvesting is less well documented. In this study we constructed a nutrient budget for a selective harvesting regime in Haliburton Forest, central Ontario. Atmospheric deposition (5-year average) and mineral weathering (PROFILE) where considered as inputs to the forest, while exports included nutrient losses in streams and removed in timber. Mass balance calculations indicate that in the absence of harvesting only slight losses of Ca and S would occur, but that relative to soil pool sizes losses are insignificant (Table 1). When harvesting is considered net losses of Ca, K, Mn, N and S are observed, but the magnitude of loss depends on whether best case (inputs increased by 20% and exports decreased by 20%), average (measured) or worst case (inputs decreased by 20% and exports increased by 20%) are assumed. If average (measured) values are lost, calculations indicate that soil reserves of Ca and K, could be depleted within a matter of decades. Uncertainties, assumptions and research needs are addressed within the presentation.

Estimated annual nutrient budgets (kg ha^{-1} y^{-1}) at Haliburton Forest. Parentheses contain an estimation of years to depletion of the current soil pool. '+' indicates annual retention and '-' indicates net loss. Worst case decreases inputs by 20% and increases export by 20%' Best case increases inputs by 20% and decreases export by 20%'

	kg ha^{-1} yr^{-1}			
nutrient	no harvest	worst	measured	best
Ca	-0.41 (2620)	-22.2 (49)	-15.0 (71)	-8.42 (126)
K	0.83 (+)	-5.88 (32)	-3.47 (55)	-1.32 (144)
Mg	0.68 (+)	-1.40 (51)	0.02 (+)	1.41 (+)
Na	4.27 (+)	1.77 (+)	4.09 (+)	6.40 (+)
Mn	0.35 (+)	-0.39 (175)	-0.21 (323)	0.06 (1074)
Al	4.48 (+)	3.56 (+)	4.46 (+)	5.35 (+)
Fe	7.00 (+)	5.22 (+)	6.67 (+)	8.10 (+)
P	0.30 (+)	0.04 (+)	0.16 (+)	0.27 (+)
N	7.35 (+)	-4.74 (2960)	-1.06 (13200)	2.14 (+)
S	-0.19 (13200)	-4.81 (519)	-1.82 (1370)	1.07 (+)

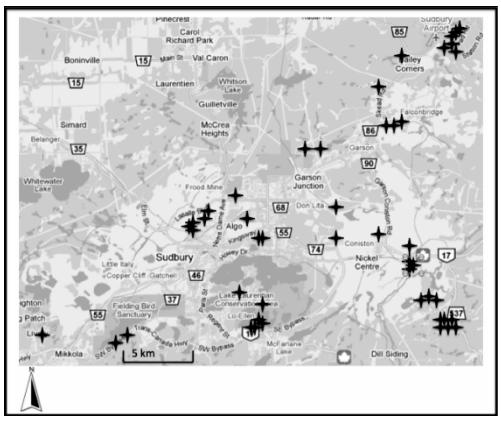
The Introduction of Native Understory Woodland Species on Reclaimed Mine Lands

Santala, K.R.
Laurentian University

Introduction of herbaceous woodland species has been supported as a feasible approach to enhance biodiversity and ecosystem function of industrially impacted woodlands. Studies of transplants usually focus on variations in transplant method. Few studies have attempted to determine which environmental characteristics most influence woodland species transplants success in reclaimed forests. The goal of my proposed study is to evaluate understory woodland species transplant establishment along a gradient of metal contamination and to relate successful establishment to biotic and abiotic site characteristics.

During the summer of 2010 woodland species transplant plots, each 16m^2 in area, were installed throughout Cu-Ni smelter damaged areas of the City of Greater Sudbury (Ontario) (Figure 1). Transplanted species along with their associated soils were salvaged from an area slated for the development of a new highway 50 km south of Sudbury. Beginning in the summer of 2011, species survival and changes in cover and composition of the transplants will be determined using a point frame method. Position of individuals emerging from the plots will be digitized using information gathered from point frame method or through fixed position photography. To determine the ability of transplanted species to colonize new soils, ingrowths cores containing surrounding soils and transplant soils will be inserted within transplant plots to compare root growth over one growing season. The soils from the transplant plots and surrounding areas will be analyzed for phytoavailable elements, CNS, pH/conductivity, and cation exchange capacity within the underlying substrate. To determine the influence of canopy type on transplant establishment, canopy closure and percent photosynthetic active radiation reaching the plots will be measured using a spherical densitometer and photosynthetic active radiation light sensor respectively. Temperature data loggers will also be installed to determine differences in growing degree days and microclimate. Multiple regression techniques will be then used to determine the parameters most linked with the success of woodland transplants.

Information gathered from this study will assist in site selection when introducing understory woodland species in reclaimed forests of mine and smelter-impacted lands. It will also provide incite into the control of biodiversity in ecosystem restoration.

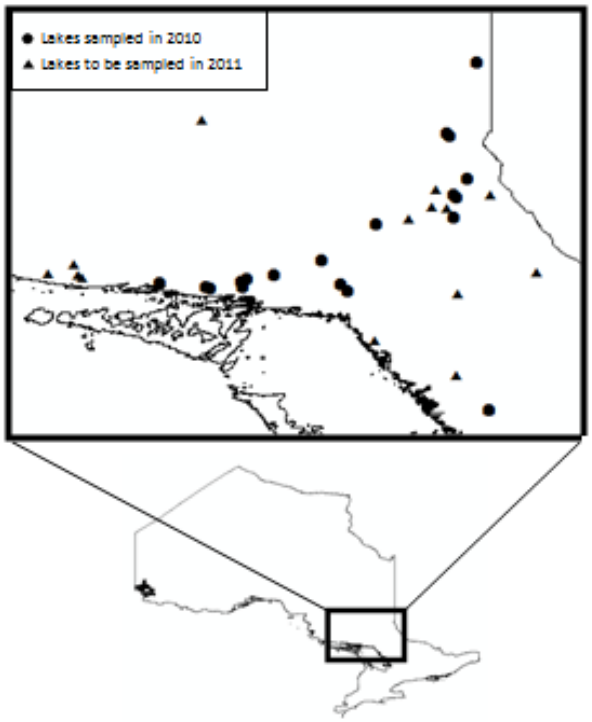


Locations of transplant sites in the City of Greater Sudbury.

The Role of DOC in Diet Partitioning Between Walleye (*Sander Vitreus*) and Smallmouth Bass (*Micropterus Dolomieu*) in Boreal Shield Lakes

Stasko, A., Gunn, J., and Johnston, T.*
Cooperative Freshwater Ecology Unit, Laurentian University

The northern invasion of smallmouth bass *Micropterus dolomieu* into Boreal Shield lakes has recently sparked concern among fisheries managers about the effects that bass will have on native walleye *Sander viteus* populations. At the same time, the warming climate is expected to cause changes in water clarity due to changing inputs of dissolved organic carbon (DOC) into lakes, which may affect the foraging efficiency of these two visual predators. This study will test the hypotheses that, as waters become clearer, the isotopic niche space of walleye will expand (indicating more generalized diets), while that of smallmouth bass will contract (indicating more specialized diets), and that the amount of isotopic niche overlap will increase. Dorsal muscle tissue will be collected for stable isotope analysis from 20 walleye and 20 smallmouth bass from each of 30 lakes across northeastern Ontario that span a wide gradient of DOC concentrations. Stable isotope values of $\delta^{15}N$ and $\delta^{13}C$ will be plotted in bivariate space and used to create variance-based measures of isotopic trophic niche space (area of a variance ellipse, mean distance of individuals to centroid, coefficient of variation of distances from each individuals to all neighbours) and isotopic niche overlap (area of overlap between variance ellipses, distance between population centroids). These measures will be compared among lakes across the DOC (water clarity) gradient.

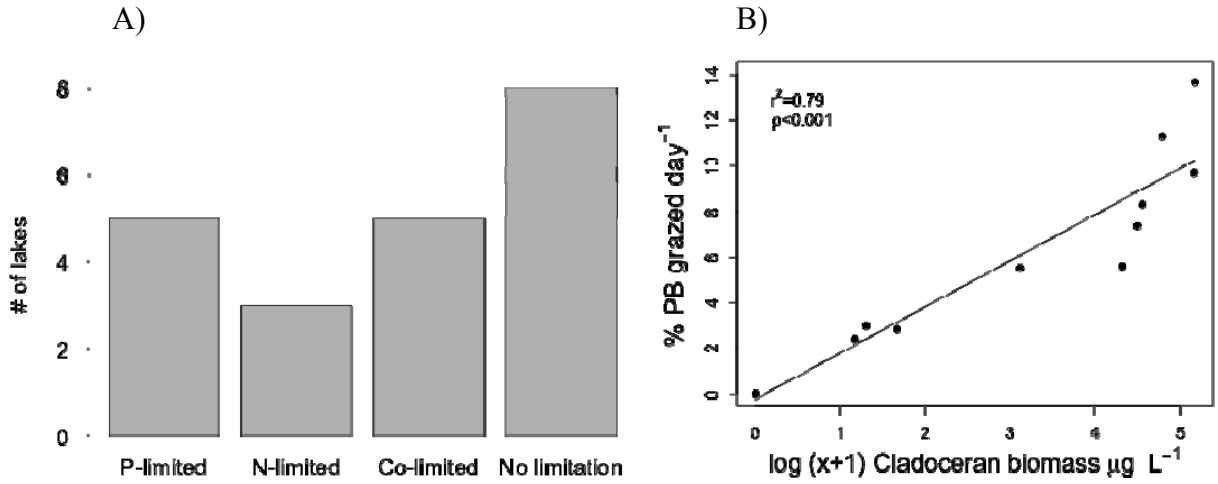


Map of 30 study lakes across southern and northeastern Ontario.

Nutrient Limitation and Zooplankton Grazing Control of Phytoplankton Biomass in Subarctic Lakes, Wapusk National Park, Manitoba

Symons, C.[1], Arnott, S.[1] & Sweetman, J.[2]
[1]Queen's University, [2]Parks Canada,

Understanding how ecosystems will respond to environmental change is particularly important in northern regions, as climate change is predicted to have profound effects in this area. In the subarctic, melting permafrost is expected to affect lake chemistry through changes in the cycling of nutrients and organic matter. In an effort to understand how aquatic ecosystems in subarctic regions will respond to future climate change, we assessed the bottom-up and top-down control of phytoplankton biomass using nutrient enrichment bioassays and a zooplankton community grazing experiment. Although 38% of lakes' phytoplankton communities did not respond to N or P additions, the remaining 62% were limited by nitrogen, phosphorus or co-limited by both nutrients, suggesting phytoplankton biomass may increase as more nutrients are available. Zooplankton grazing can control phytoplankton biomass; however, the results from the grazing experiment suggest that zooplankton community grazing rates are low (mean: 6% of phytoplankton biomass grazed per day) compared to average community grazing rates in temperate regions. Cladoceran biomass is the most important predictor of grazing rate, and accounted for 79% of variation in grazing rates among lakes . Overall, the bottom-up and low top-down control on phytoplankton biomass suggests climate change will likely have a large impact on lake productivity in this region.

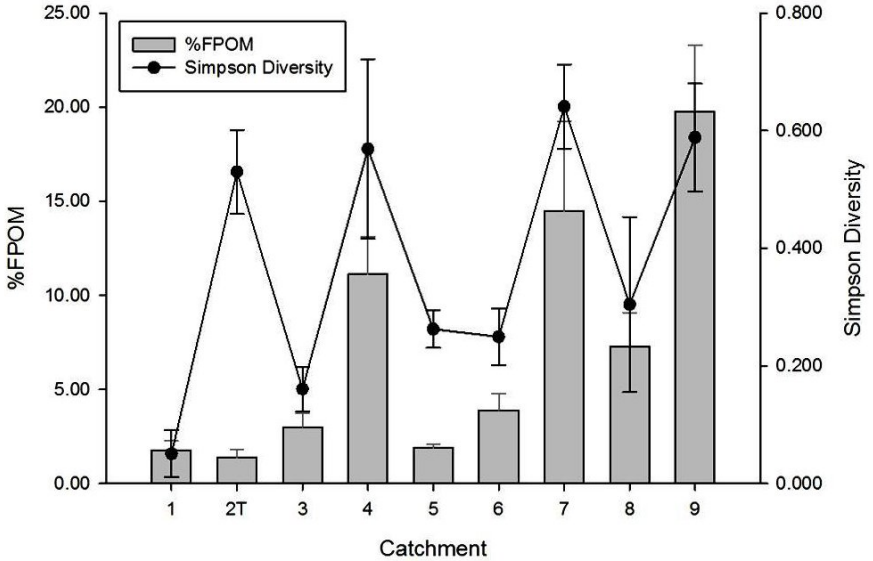


A) The categories of nutrient limitation found in 21 lakes and ponds and B) the relationship between zooplankton community grazing rate (% phytoplankton biomass (PB) grazed per day) and cladoceran biomass

Internal Processing of Nutrients and Metals in Wetlands and Associated Fluxes: Importance to Early Successional Aquatic Communities in Recovering Watersheds

Szkokan-Emilson, E.[1], Watmough, S.[2], and Gunn, J.[1]*
[1]Cooperative Freshwater Ecology Unit, Laurentian University, [2]Environmental Resource Science, Trent University

Allochthonous inputs of nutrients play an important role in structuring lake communities, and terrestrially-derived carbon has been shown to be particularly important in lakes in the early stages of recovery and succession. Lowland wetlands are the sites of many biogeochemical transformations, and can retain and/or be sources of mobilized metals, carbon, and other nutrients to downstream lakes. In cases where the vegetation and soils of terrestrial systems are recovering in concordance with aquatic systems, the biogeochemical processes occurring in these wetlands plays an even more important role in structuring the delivery of allochthonous materials. The objectives of this study are to determine how biogeochemical cycling of nutrients and metals differs across six wetlands of recovering watersheds, and to investigate differences in the loads of these allochthonous materials across their outflow streams. One of the catchments will be fitted with ISCO automated high-frequency samplers to assess the impact of short-term pulses of nutrients and metals from uplands and wetlands during flash events that may be common in these highly-impacted catchments. Specific attention is paid to structural properties of carbon exports related to lability and availability to aquatic communities. The spatial patterns in littoral communities are explored in one watershed, in relation to large gradients in allochthonous carbon and other nutrients. This research provides a better understanding of the concordance between terrestrial and aquatic succession in recovering watersheds, opening up the potential for management practices to accelerate the succession of whole ecosystems.



Spatial patterns of benthic macroinvertebrate diversity correlate positively to the availability of allochthonous, wetland-derived organic matter in a recovering watershed.

Temporal Trends in Mercury Concentrations of Large-Bodied Fishes in Northern Ontario Lakes

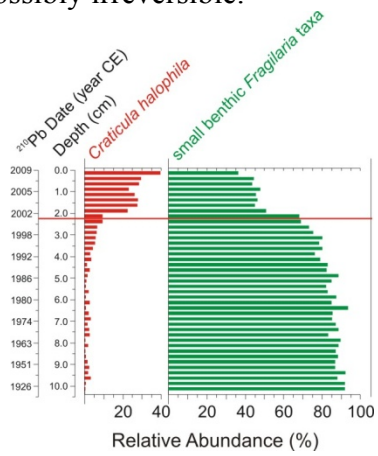
Tang*, R.W.K., Johnston, T.A., Gunn, J.M.
Cooperative Freshwater Ecology Unit, Laurentian University

Bioaccumulation of mercury in fish is an environmental concern responsible for most fish consumption advisories on lakes of Northern Ontario. Atmospheric deposition is believed to be the primary source of inorganic mercury to undisturbed boreal lakes. The Ontario Ministry of Environment (OMOE) has been monitoring fish mercury concentrations in Ontario waters for over 30 years. Using historic fish mercury data from the OMOE long-term monitoring database, and current fish mercury data from a new sampling program, we examined changes in mercury bioaccumulation by seven fish species in lakes from across Northern Ontario following a paired-comparisons approach. We predicted that mercury concentrations of most species would have declined over the last 30 years. Mercury concentration vs body size slopes did not change appreciably from historic to current sampling periods. Mean predicted mercury concentrations (standardized to a 1-kg fish) increased slightly over the last 30 years in all species. However, this change was not statistically significant for any of the study species and there was no indication that the nature of the temporal change varied geographically. The potential for future changes in fish mercury concentrations will be discussed in relation to changing atmospheric mercury deposition and climate-mediated changes in methylation rates and fish growth rates.

Marine Storm Surge Damage to Arctic Freshwater Ecosystems

Thienpont, J.[1], Nesbitt, H.[1], Deasley, K.[1], Korosi, J.[1], Kokelj, S.[2], Pisaric, M.[3] and Smol, J.[1]*
[1]Queen's University, [2]Department of Indian and Northern Affairs Canada ,[3]Carleton University

Low-lying coastal environments around the world are threatened by rising sea levels due to climate change. In northern regions, higher sea levels combined with decreased sea ice cover and more intense storms are believed to be placing low-lying coastal communities especially at risk. In the ecologically sensitive and globally significant Mackenzie Delta of northwest Canada, ecosystems are adapted to freshwater flooding associated with spring breakup. Marine storm surges during the open-water season that move saltwater into the delta can have damaging impacts on terrestrial and aquatic systems. In order to track the impact of a recent marine storm surge we used a paleolimnological approach to determine the impact of the subsequent saltwater inundation on freshwater ecosystems, as well as to assess the frequency of past storm surge events. Through an examination of diatoms in dated sediment cores we present disturbing evidence that this recent storm surge completely altered the ecological functioning of this system and abruptly shifted it from a freshwater system to a saline/brackish environment that resulted in significant change to the aquatic system. What is of particular significance is that the level of this recent ecological damage is unprecedented over the >1,000-year history of this ecosystem. Through the analysis of sedimentary cladoceran remains we see that the surge also impacted higher trophic levels in the system, resulting in a decrease in the complexity of the cladoceran community. We infer that no biological recovery has occurred in these lakes, over a decade later, suggesting these systems may be on a new ecological trajectory. As climate continues to warm and sea ice declines in this region, similar inundations will likely be repeated in other coastal areas of the circumpolar Arctic. Given the fragility of these ecosystems, such ecosystem changes may prove to be long-lasting or possibly irreversible.



Relative frequency diagram of brackish *Craticula halophila* and freshwater benthic *Fragilaria* from impacted Lake DZO-29 over last ~90 years. Red line represents largest change in diatom assemblage, and corresponds to the 1999 storm surge event based on ^{210}Pb dating.

Notes

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