Science For a Changing North

2009 Sudbury Restoration Workshop
Oct. 27-29, Laurentian University

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

Details Subject to Change

2009 Sudbury Restoration Workshop -Science For a Changing North

October 27-29, 2009 Laurentian University

Time	Tuesday Oct. 27, 2009	Location
4:30 PM	Registration/Check in and Poster Set up	Fraser Lobby
6:30 PM	20th Anniversary CFEU Homecoming	Dooly's (Regent St.)
Time	**Wednesday Oct. 28, 2009**	**Location**
8:00 AM	Registration, Poster Set up **Coffee**	Fraser Lobby
8:45 AM	Opening	Lower Fraser
9:30 AM	John Smol, Queen's University, Environmental Trends in the High Arctic: Lessons From the Past	Lower Fraser
10:30 AM	**Coffee**	Fraser Lobby
11:00 AM	Martyn Obbard, OMNR, Current Status of the Southern Hudson Bay Polar Bear Population	Lower Fraser
11:35 AM	Cathy Nielson, OMNR, Information and Knowledge for Land Use Planning in the Far North	Lower Fraser
12:00 PM	**LUNCH - Science Café with Far North Panel**	Alumni Hall
1:00 PM	Nigel Roulet, McGill University, Northern Wetlands, Carbon Fluxes and Climate	Lower Fraser
1:45 PM	Justina Ray, WCS/ University of Toronto, Ontario Caribou in a Changing North	Lower Fraser
2:15 PM	Ken Abraham, OMNR, Waterfowl Population Changes in the Hudson Bay Lowlands	Lower Fraser
2:45 PM	**Break - Poster Session with Authors Present**	Fraser Lobby
3:15 PM	Jonathan Fowler, VP DeBeer's Ltd, Aboriginal Affairs, Victor Diamond Mine Building Consensus: Community Involvement from Exploration through Development to Mining	Lower Fraser
3:45 PM	Paul Semple , COO Noront Resources, Noront and the Potential Development of the Ring of Fire, James Bay, Lowlands	Lower Fraser
4:15 PM	Daniel Campbell, Laurentian University, The Rehabilitation of Disturbed Peatlands and New Uplands in the Hudson Bay Lowland	Lower Fraser
4:45 PM	**Poster Session with Authors Present (Cash Bar)**	Fraser Lobby
6:00 PM	**Banquet** Guest Speaker: David Lickley, Science North, IMAX and the N.W. Passage, Musical Performance: Allison Lickley	Alumni Hall
Time	**Thursday Oct. 29, 2009**	**Location**
7:00 AM	Sunrise Celebration Walk- Tour of Living with Lakes Centre Site	Fraser Lobby
8:30 AM	**Coffee**	Fraser Lobby
9:00 AM	Concurrent Sessions (Forest Dynamics and Climate Change, Science and Indigenous Knowledge, Mining Community - Stakeholders Act)	Fraser Bldg.
10:00 AM	**Break**	Fraser Lobby
10:30 AM	Concurrent Sessions (Forest Dynamics and Climate Change, Science and Indigenous Knowledge, Mining Community - Stakeholders Act)	Fraser Bldg.
12:00 PM	**Lunch**	Alumni Hall
1:00 PM	Concurrent Sessions (Community and Sectoral Response to Climate Change Impacts, Climate Change and Multiple Stressors)	Fraser Bldg.
3:00 PM	**Break**	Fraser Lobby
3:30 PM	Concurrent Sessions (Community and Sectoral Response to Climate Change Impacts, Climate Change and Multiple Stressors)	Fraser Bldg.
5:00 PM	Pub Night	LU Pub

Thursday, October 29,
Concurrent Sessions

Details Subject to Change

	Concurrent Sessions		
Location	**Upper Fraser Left**	**Lower Fraser**	**Upper Fraser Right**
Session	**Forest Dynamics and Climate Change**	**Science and Indigenous Knowledge**	**Mining Community - Stakeholders Act**
Host	**Madhur Anand**	**Darrel Manitowabi**	**Peter Beckett, Graeme Spiers**
9:00 AM	Sean Thomas, U of T, Forest Responses to Environmental Change: Evidence from a Global Network of Forest Megaplots	Cheryl Recollet, McGill, Indigenous Peoples and Impact Assessment: The Environmental Assessment Framework and the Role of Traditional Knowledge	"The Junction Creek Clearwater Revival", Junction Creek Stewardship Committee, 10th Anniversary Film plus Commentary
9:30 AM	Timothy Lynham, Can. Forest. Serv., Forest Fires and Carbon Accounting	Michael O'Flaherty, Independent Consultant, The Struggle to Find a Balance: Pikangikum First Nation and the Whitefeather Forest Initiative	Alan Lock, Graeme Spiers, Jennifer Hargreaves , Peter Beckett, Tamara Posadowski and Samantha Smith, Mirarco + Laurentian University. Can Tailings Produce Useful Biocrops?
10:00 AM	**Break**		
10:30 AM	Madhur Anand, U of G, Natural Disturbance, Climate Change and Forests	Lorrilee McGregor, Whitefish River First Nation, Respect and Reciprocity: Engaging in Discussions with Indigenous People About Traditional Knowledge	Chris Wren, Mirarco, Laurentian University, The Sudbury Soils Study Ecological Risk Assessment
11:00 AM	Elizabeth Nelson, PhD candidate U of T, Boreal Tree Growth Patterns in a Changing Climate: Evidence from Dendrochronology	Julie Ozawagosh, Atikameksheng Anishinabek, Traditional Knowledge: An Elder's Perspective	Stephen Monet, City of Greater Sudbury, Sudbury's New Biodiversity Action Plan
11:30 AM	Lucas Silva, PhD Candidate U of G, Temperate and Boreal Tree Growth Declines in Spite of Increasing Atmospheric CO_2	Discussant Jennifer Simard, Mushkegowuk Environmental Research Centre	Fallon Kirkey, Peter Ryser. Laurentian University, Indication of Low-Level Metal Tolerance in Sudbury Red Maple (*Acer rubrum*)
12:00 PM	**Lunch**		
Session	**Community and Sectoral Response to Climate Change Impacts**	**Climate Change and Multiple Stressors**	
Host	**Al Douglas OCCIAR**	**Bill Keller**	
1:00 PM	David Pearson, Co-Chair of Ontario's Expert Panel on Climate Change Adaptation, Climate Impacts and Adaptation in the Far North of Ontario – Change Like No One Has Seen Before?	Jules Blais, U of Ottawa, The impact of thawing permafrost on lakes of the Mackenzie Delta.	
1:30 PM	Neil Comer, Environment Canada, Climate Change Models, Verification and Ensembles – An Ontario Focus	Shelley Arnott, Queens, Potential Climate Impacts on Lakes in Wapusk National Park	
2:00 PM	Al Douglas, MIRARCO, Climate Change in Northern Ontario – Community Vulnerabilities and Risks?	Andrew Paterson, OMOE Dorset, Evidence of Recent Environmental and Climatic Change in the Lake of the Woods, Ontario	
2:30 PM	Laurie Tucar – North South Climate Change Network	Kathleen Rühland, Queens, Diatom Community Responses to Recent Warming and Other Stressors in the Lake of the Woods and Beyond	
3:00 PM	**Break (Poster Display)**		
3:30 PM	Jason Prno, Trailhead Consulting, Climate Change and Canadian Mining: Opportunities for Adaptation	Michelle Palmer, York U, Climate and Morphometry Drive Asynchronous Temporal Patterns in Lake Thermal Dynamics and Oxygen Content	
4:00 PM	Greg Ross and Dan Waddell, OCCIAR - Mirarco, Great Lakes Water Levels in a Changing Climate: Vulnerabilities of the Recreational Boating Sector	Keith Somers, OMOE Dorset, Using Redundancy Analysis to Quantify the Cumulative Effects of Multiple Stressors	
4:30 PM		Shannon MacPhee, Laurentian University, Lake Thermal Regime and Crustacean Zooplankton Community Structure	
5:00 PM		Bill Keller, Laurentian University, Limnology in Ontario's Far North: An Introduction	

Abstracts Oct. 28th, 2009
Plenary Speakers

John Smol, Queen's University
Environmental Trends in the High Arctic: Lessons From the Past

Nigel Roulet, McGill University
Northern Wetlands, Carbon Fluxes and Climate

Cathy Nielson, OMNR
Information and Knowledge for Land Use Planning in the Far North

Justina Ray, WCS/ University of Toronto
Ontario Caribou in a Changing North

Martyn Obbard, OMNR
Current Status of the Southern Hudson Bay Polar Bear Population

Ken Abraham, OMNR
Waterfowl Population Changes in the Hudson Bay Lowlands

Jonathan Fowler, DeBeers Canada Ltd. VP Aboriginal Affairs,
Victor Diamond Mine Building Consensus: Community Involvement from Exploration through Development to Mining

Paul Semple , COO Noront Resources
Noront and the Potential Development of the Ring of Fire, James Bay, Lowlands

Daniel Campbell, Laurentian University
The Rehabilitation of Disturbed Peatlands and New Uplands in the Hudson Bay Lowland

Environmental Trends in the High Arctic: Lessons From the Past

John P. Smol
Paleoecological Environmental Assessment and Research Lab,
Dept. Biology, Queen's University

We live in a constantly changing environment. Yet tracking ecological changes is often very difficult, as long-term monitoring data are frequently lacking, and are especially sparse from Arctic ecosystems where logistical difficulties limit most monitoring programs. Fortunately, lake and pond sediments contain important archives of past limnological communities that can be used to reconstruct environmental changes. In this talk, I summarize collaborative work (primarily with M. Douglas and our students) of some paleolimnological studies that have documented recent climatic warming in Arctic lakes and ponds. Several hypotheses have been tested to determine if warming, resulting in changes in ice cover and related variables (e.g. increased habitat availability, shifts in other limnological characteristics), were the factors most strongly influencing recent diatom and other biotic changes. These data showed that striking and often unprecedented community changes are evident in post-1850 sediments, and can be linked to ecological shifts consistent with warming. I will also dovetail our paleolimnological data spanning several millennia with our 27-year window of on-site monitoring data to show how shallow ponds on Cape Herschel (Ellesmere Island) have changed dramatically over the last century, and especially over the last few years. Some of these ponds, which paleolimnological data indicate have been permanent water bodies for millennia, have now completely desiccated. The final ecological threshold for these aquatic ecosystems has now been crossed: complete desiccation.

Other recent collaborative work (especially with Jules Blais and Mark Mallory, and other researchers in our labs) has focused on the development of paleolimnological techniques to track the influence of Arctic seabirds on freshwater ecosystems. For example, the cliffs of Cape Vera (Devon Island) are the nesting sites for over 10,000 pairs of breeding northern fulmars. The guano from these large seabird colonies drains into the ponds below the cliffs, thus markedly altering the limnological characteristics of these sites. Sedimentary analyses are revealing many interesting features of pond development and contamination as a result of these marine-derived influences. Such paleolimnological data may also be used to track the long-term patterns of seabird populations. In addition, these studies provide important paleolimnological reference sites for studying the interacting effects of climatic change, long-term eutrophication (and recovery), as well as the past sources of marine-derived nutrients and other contaminants (e.g. DDT, PCB, Hg) on high Arctic ecosystems.

Smol, J.P. and Douglas, M.S.V. 2007. From controversy to consensus: making the case for recent climatic change in the Arctic using lake sediments. Frontiers in Ecology and the Environment 5: 466-474.

Smol, J.P. and Douglas, M.S.V. 2007. Crossing the final ecological threshold in high Arctic ponds. Proceedings of the National Academy of Sciences 104: 12395-12397.

Michelutti, N., Keatley, B.E., Brimble, S., Blais, J.M., Liu, H., Douglas, M.S.V., Mallory, M.L., and Smol, J.P. 2009. Seabird-driven shifts in Arctic pond ecosystems. Proc. Roy. Soc (Lond), Series B 276: 591-596.

Northern Wetlands, Carbon Fluxes and Climate

Nigel Roulet
Department of Geography, McGill School of Environment, and the Global Environmental and Climate Change Centre, McGill University

The role of northern wetlands in the climate system stems from their role in the global carbon cycle, and specifically the net ecosystem exchanges of carbon dioxide (CO_2) and methane (CH_4). Over 90% of northern wetlands are peatlands: bogs, fens and swamps. Estimates vary considerably but northern peatlands store between ~ 20 and 30% of Earth's terrestrial carbon and account for between ~ 5 to 15% of the annual emissions of CH_4 to atmosphere. The uncertainty in the global carbon store and global gas exchanges are large and the uncertainties are even larger at regional and local scales, but Ontario's north contains between 5 and 10% of the world's northern wetlands, hence they are significant.

Back-of-the-envelope calculations of long-term removal of CO_2 and emission of CH_4 from peatlands suggest they could represent a -0.5 W m^{-2} reduction in global radiative forcing (equivalent to ~ 10 to 20% of anthropogenic climate forcing since ~ 1700). Peatlands, exchange three greenhouse gases whose biogeochemistry has very different rate constants and element cycling times. Two of these gases, CH_4 and N_2O have an atmospheric chemistry and a third, CO_2, does not – i.e. the fate of CO_2 fate is completely dependent on the biology and chemistry of other terrestrial ecosystems and the oceans.

Understanding the processes that regulate the exchange of CO_2 and CH_4 well enough to be able to generalize for simulating the response of peatlands to environmental change, such as the direct and indirect consequences of climate and/or land cover changes, is a not a trivial problem. Not only do these estimates require good descriptions of the structure and function of ecosystem biogeochemistry, but in the case of peatlands an equally good description of the physical attributes of the energy exchanges and hydrology is required. Relatively small changes in the moisture storage (5 – 10%) and temperature (2 – 3°C), which in many other ecosystems would lead to small changes, in peatlands can cause much larger changes in the production and decomposition of C. Persistent changes in moisture (e.g. water table changes of ±5 – 10 cm) can alter the structure of the plant community that leads to orders of magnitude change in CH_4 exchange. While the change in the mass flux of C may be small, the change in the species of trace gas could have a profound effect. The first models to attempt to assess the overall change in greenhouse emissions from peatlands suggest the response could range from effectively zero change to as large as a ~ 1 Pg C yr^{-1} source to the atmosphere by 2100 for the worst case scenario. For reference, the current anthropogenic emissions are 8 – 9 Pg C yr^{-1} and by 2100 they may be as large as 20 – 25 P C yr^{-1}.

Peatlands are recognized to have the characteristics of self-regulating systems and the extent of regulation is a function of the peatland type and the source of water and nutrients. A critical question is whether climate change will push some peatlands beyond their envelope of self-regulation. Certain changes, such as the melting of permafrost, have the potential to very rapidly send the ecosystem off on a trajectory that will result in a different form of peatland with a very different structure and function.

Information and Knowledge for Land Use Planning in the Far North

Cathy Nielson, Ontario Ministry of Natural Resources

The Far North Planning Initiative is focused on land use planning in the Far North to ensure conservation in balance with environmentally sustainable development. One of the foundations for planning and resource management is information about the physical and biological landscape for the area of interest. This presentation will provide an overview of progress for the Far North Information and Knowledge Management initiative which is designed to address critical gaps in information and knowledge required to support planning and resource management decision making in the Far North.

Ontario Caribou in a Changing North

Justina C. Ray
Wildlife Conservation Society Canada

Caribou (*Rangifer tarandus*), an ungulate with a circumboreal distribution, has experienced widespread population declines across Canada, rendering it the subject of much conservation attention. Caribou are among the most challenging elements of boreal biodiversity to conserve owing to factors such as their inherent low reproductive capacity, their association with older coniferous forests and their naturally low densities. Both major caribou ecotypes (migratory and sedentary) reside in Ontario, where the species once ranged as far south as Lake Nipissing. Maintaining its current stronghold in the northern half of the province will be an important test under scenarios of an expanding resource extraction mandate and a changing climate. This presentation will review the status of caribou in Ontario through the lens of caribou ecology and conservation in Canada at large. Bringing insights from recent analyses conducted under the auspices of a recently-completed scientific review of boreal caribou Critical Habitat in Canada, I will focus on caribou as a "focal species" that should provide a means to manage cumulative effects in sensitive Far North environments.

Present-day caribou distribution in North America and southern extent of historical occurrence (1880's).

Current Status of the Southern Hudson Bay Polar Bear Population

Martyn E. Obbard
Wildlife Research and Development Section
Ontario Ministry of Natural Resources

Polar bears in Hudson Bay are at risk due to changes in the distribution and duration of sea ice that have already occurred or are predicted to occur in the near future (within 50-100 y). For example, the Western Hudson Bay subpopulation, which summers on land in Manitoba, has shown declines in body condition and has declined in abundance by >20% in the past 2 decades. The Southern Hudson Bay subpopulation, which summers on land in Ontario, is less well studied and its status is less well known by the public. However, recent work indicates that body condition for all age and sex classes declined significantly between the mid-1980s and currently. In addition, though results of a recently-completed capture-recapture study suggest that there has been no change in abundance in the past 2 decades, there is evidence of declines in survival for all age and sex classes. This information, coupled with the projected changes to sea ice in the future, suggests that the Southern Hudson Bay subpopulation may be at a tipping point. Declines in abundance similar to those experienced by the Western Hudson Bay subpopulation can be expected in the near future.

Waterfowl Population Changes in the Hudson Bay Lowlands

Kenneth Abraham
Ontario Ministry of Natural Resources

The Hudson Bay Lowland is host to millions of waterfowl and other water birds annually during their migration, breeding and moulting periods. Although some groups and species have declined in recent decades, notably shorebirds and sea ducks, others have increased, notably geese. Indeed, several populations of geese in North America have increased to record high levels. These increases are part of a long-term trend due to anthropogenic influences outside the Hudson Bay Lowlands in the form of energy-nutrient subsidies to geese from agricultural by-products (spilled grain in harvested fields, high nitrogen pastures, etc.) with the net effect being the removal of density-dependent regulation of populations in the non-breeding season. While the energy-nutrient subsidy does not operate directly on the breeding grounds, the negative effects of the population increase are expressed there more clearly than elsewhere. In the Hudson Bay Lowland, this has meant unprecedented foraging pressure on coastal marshes where the majority of waterfowl and waterbirds stage, nest and rear young. These habitats have become degraded at several locations with negative consequences on ecosystem processes and species. Recovery of coastal ecosystems depends on multiple factors, but in all cases appears to be a process requiring many decades with uncertain outcomes.

Victor Diamond Mine Building Consensus: Community Involvement from Exploration through Development to Mining

Jonathan A. Fowler
De Beers Canada Inc.

The Victor diamond mine is the first diamond mine in Ontario and De Beers' second diamond mine outside Africa. It lies within the traditional lands of the Attawapiskat First Nation. Discovered in late 1987, work progressed to prove the viability of the deposit until 2002, when an environmental assessment started. In parallel with the exploration and evaluation programs, De Beers Canada undertook a community engagement program that continues today. A production decision was taken in 2005 upon the successful completion of both the negotiation for an impact benefit agreement ("IBA") and the environmental assessment process. As part of the community engagement, it was important to ensure that the community had sufficient information upon which to base its decisions in sufficient time to influence decisions before the membership voted in a ratification process to either support or reject both the IBA and the proposed mine development. The vote was affirmative with an 85% approval of those who voted both on and off-reserve.

Building consensus and a relationship with any community takes time and persistence. Consensus does not mean a unanimous decision: there will usually be dissenters. Attawapiskat is no different. De Beers does not have all the answers, and this overview provides a vignette of some of the issues that arose and are happening today; and how these were addressed. Engagement followed a progression from information sharing, through dialogue, and consultation to involvement, collaboration and then empowerment. This did not happen overnight. Sometimes there was a step back as the relationship progressed. It was not a simple linear progression.

Continuity was important in both messages and messengers, as well as stating clearly what it was that De Beers intended to do, reporting back on what it had done and being able to demonstrate this. Hurdles of cross-cultural communication, absence of words in Cree for many technical terms and concepts, and relatively low comprehension levels in the community, together with erratic attendance at public meetings presented some interesting obstacles to be overcome. Team work, patience and continuing discussions with the community and its leadership produced useful guidance on better ways to pass on the messages.

A good neighbour and partner approach has served well focusing on a "hand up" rather than a "hand out" and has been effective in taking the first steps towards a sustainable relationship. Currently there are internal issues and a series of crises within the community. The company has to work with the community and support it while providing what assistance it can. A company is not a substitute for government: De Beers cannot provide all the solutions to the many infrastructure and social problems. It can use its proven strengths to assist in areas of project management, procurement and logistics and leverage these to help the community by being a good neighbour, and by working to correct unreasonable expectations to more realistic ones.

The relationship continues to evolve.

The Rehabilitation of Disturbed Peatlands and New Uplands in the Hudson Bay Lowland

Daniel Campbell
Department of Biology, Laurentian University

The Hudson Bay Lowland (HBL) is the third largest wetland in the world, occupying 3.5% of Canada's land mass. Increasingly, mining projects are proposed or starting operations in this remote subarctic region. The De Beers Victor project is the first mine in the HBL. They are extracting diamonds from an open pit. Our objectives are to determine suitable protocols for the rehabilitation of peatlands disturbed from this mine and the reclamation of uplands formed from mining waste. We are working towards developing these protocols using a four pronged approach: 1) testing and modifying existing restoration protocols for peatland from south boreal regions; 2) determining potential reference conditions for the reclamation of uplands; 4) creating suitably fertile soils from existing mining wastes; and 4) identifying candidate plant species to support the long-term revegetation of these uplands. Early results suggest that the spreading of Sphagnum moss fragments is sufficient to revegetate most disturbed peatlands associated with the mine. Winter ice roads, once closed, revegetate well towards natural peatlands with minimal intervention, although this will take time. We have surveyed reference conditions for new uplands in natural isolated uplands within the HBL as well as on uplands along the Attawapiskat River. A functional soil appears to be possible using mixes of processed kimberlite, ground limestone, waste rock, silty clays and peat. Early results also identify several candidate native plant species which could be used in successional vegetation sequences on reclaimed soils. We believe that protocols developed here will be useful for the rehabilitation of mines and other disturbed lands across the HBL and other subarctic regions.

Abstracts Oct. 29th, 2009
Concurrent Sessions
Speaker Abstracts

Forest Dynamics and Climate Change
Host: Madhur Anand, University of Guelph

Sean Thomas, University of Toronto
Forest Responses to Environmental Change: Evidence from a Global Network of Forest Megaplots

Timothy Lynham, Canadian Forest Service
Forest Fires and Carbon Accounting

Madhur Anand, University of Guelph
Natural Disturbance, Climate Change and Forests

Elizabeth A. Nelson and Sean C. Thomas, University of Toronto
Boreal Tree Growth Patterns in a Changing Climate: Evidence from Dendrochronology

Lucas C. R. Silva, Madhur Anand and Mark Leithead, University of Guelph
Temperate and Boreal Tree Growth Declines in Spite of Increasing Atmospheric CO_2

Forest Responses to Environmental Change: Evidence from a Global Network of Forest Megaplots

Sean C. Thomas
Faculty of Forestry, University of Toronto

Recent studies in tropical forests have suggested several trends consistent with long-term, pervasive changes in forest dynamics driven by anthropogenic environmental change. Such changes include increasing biomass accumulation in undisturbed forests, increasing tree turnover rates, increasing abundance of woody vines, and changes in tree species composition favoring fast-growing over slow-growing tree species. I review recent analyses of changes in forest dynamics based on a worldwide network of large mapped forest plots (the Global Forest Observatory Network), and from a new network of small forest plots in tropical Africa. There is strong support for a pattern of increasing biomass accumulation in primary forests globally, with a revised estimate of the net C sink in primary tropical forests of 0.49 MgC ha^{-1} y^{-1}. However, analyses from large mapped plots do not indicate increasing biomass turnover or a disproportionate increase in fast-growing species. Rather, gradual increases in slower-growing species with dense wood are found in most plots. A detailed analysis from large plots in the Ituri Forest, Democratic Republic of Congo, indicates that biomass increase is closely linked to the gradual spread of a single tree species, *Gilbertiodendron dewevrei* (Caesalpinaceae). I conclude that large mapped forest plots, as a complement to networks of small plots, provide essential information necessary to understand the ecological processes underlying changes in forest dynamics driven by anthropogenic environmental change. As home to 10% of the world's forests, Canada should be playing a central role in expanding the Global Forest Observatory Network to effectively encompass temperate and boreal forests.

Forest Fires and Carbon Accounting

Timothy J. Lynham
Canadian Forest Service, Natural Resources Canada

Short for Fire Monitoring, Accounting and Reporting System, FireMARS is a complex system for reporting carbon emissions from forest fires that uses satellites to detect high-temperature areas called hotspots. Data on these hotspots, details such as the location, size and energy of active fire fronts provide critical information for the forest managers who monitor wildfires, and for those who calculate carbon emissions from those fires.

FireMARS was created at NRCan by experts in fire science (from the Canadian Forest Service) and remote sensing (from the Canadian Centre for Remote Sensing). The Canadian Space Agency contributed funding for five years.

Thanks to this collaboration, Canada is one of the first countries to have a national system for reporting annual carbon emissions from wildfires. A system of this caliber is indispensable to help Canada fulfil its reporting obligations under the United Nations Framework Convention on Climate Change. The information from FireMARS supports other areas of forest management, such as forest certification, criteria and indicators, and the mapping of forest disturbances.

An adaptable system, FireMARS is designed to accept new sources of data as they become available. The system may soon get a boost from some advanced thermal infra-red technology that is in the works.

Natural Disturbance, Climate Change and Forests

Madhur Anand
University of Guelph

The fact that small-scale disturbances can have consequences for the longer-terms or larger-scales at which global ecological changes occur is of increasing importance. Niche-based models (also referred to as bioclimatic models, envelope models or species distribution models) of species range-shifts can have quite different predictions from process-based models (which include biotic interactions and natural disturbance). Observational studies have documented the importance of natural disturbance for accelerating range shifts. Species poised to expand their ranges may be able to take advantage of new niches created by disturbances, stress and mitigation. The role of new niches has been often studied for invasive species, but the effects of disturbance and stress on native species have not been more widely examined. A recent study suggests that, relative to other ecosystems, plant communities can have the longest recovery times emphasizing the need for restoration. It has been suggested that invasive species could undergo contraction of recently established ranges due to climate change, and this could create restoration opportunities, however identifying and establishing native or novel species where invasive species contract poses considerable challenge. These ideas will be presented in workshop style in order to incite discussion.

Boreal Tree Growth Patterns in a Changing Climate: Evidence from Dendrochronology

Elizabeth A. Nelson and Sean C. Thomas
Faculty of Forestry, University of Toronto

Climate change is occurring at an unprecedented rate in Canada's north. Our future forests will be experiencing longer, warmer growing seasons, preceded by much wetter winters. In addition to dramatic changes in climate conditions, forests are being exposed to elevated concentrations of atmospheric CO_2, which may enhance forest growth. We used annual tree ring measurements for a black spruce population from Lake Abitibi Model Forest (near Cochrane, Ontario) to determine past responses to these projected climate conditions. These past responses provide us with a reasonable estimate of future growth patterns in Canada's northern forests. Black spruce growth was enhanced by warmer conditions, and was particularly sensitive to warmer spring conditions, likely due to increased overall growing season length. Growth responses to changes in precipitation patterns were less uniform, however there was evidence that warmer, drier conditions in late summer were detrimental to overall annual growth, potentially off-setting the gains made over warm springs. Increased winter precipitation had no effect on annual growth, which may reflect the balance between the positive effect of increased water availability in the spring and summer and the negative effect of delayed onset of growing season due to increased snow cover. Finally, we modeled tree growth as explained by all of the climate variables available, and examined the residuals for a growth trend over time. We found an increase in annual growth over time that could not be explained by climate conditions, which is consistent with CO_2 fertilization in this population of black spruce. Our research at Lake Abitibi Model Forest indicates that black spruce populations are likely to benefit in the short term from increased carbon availability and lengthened growing seasons, but the capacity of these forests to take advantage of improving conditions will likely be reached sooner rather than later.

Temperate and Boreal Tree Growth Declines in Spite of Increasing Atmospheric CO_2

Lucas C. R. Silva, Madhur Anand and Mark Leithead
School of Environmental Sciences, University of Guelph

Rising atmospheric CO_2 and its synergetic interactions with warming are expected to favor tree growth in boreal and temperate forests. Here we show that conifer and deciduous trees across a large latitudinal gradient in Ontario, Canada, have indeed shown increased growth rates over the past century; more recently, however, they have shown growth decline. Similar trends were observed for young and old trees and cannot be attributed to aging. Changes in temperature and/or precipitation were not correlated to growth in most cases. Carbon isotope analysis demonstrates that loss of sensitivity to CO_2 explains this widespread decline. Unforeseen stresses may be the reason why carbon sequestration is not increasing as predicted. We suggest that a large-scale progressive nutrient limitation is the likely explanation for our results.

Science and Indigenous Knowledge
Host: Darrel Manitowabi, University of Sudbury

Cheryl Recollet, McGill University
Indigenous Peoples and Impact Assessment: The Environmental Assessment Framework and the Role of Traditional Knowledge

Michael O'Flaherty, Independent Consultant
The Struggle to Find a Balance: Pikangikum First Nation and the Whitefeather Forest Initiative

Lorrilee McGregor, Whitefish River First Nation
Respect and Reciprocity: Engaging in Discussions with Indigenous People About Traditional Knowledge

Julie Ozawagosh, Atikameksheng Anishinabek
Traditional Knowledge: An Elder's Perspective, No abstract

Discussant Jennifer Simard, Mushkegowuk Environmental Research Centre
Discussion, No abstract

Indigenous Peoples and Impact Assessment: The Environmental Assessment Framework and the Role of Traditional Knowledge

Cheryl Recollet
McGill University

Indigenous people are distinct groups that require special consideration within the Impact Assessment Framework. In Canada, environmental regulations, specifically the *Canadian Environmental Assessment Act (CEAA),* provide the opportunity to include traditional knowledge (TK) to enhance scientific data within Environmental Impact Statements (EIS). While traditional knowledge is recognized, it is not a requirement. Traditional knowledge must be accessed and utilized when the knowledge is beneficial and useful to the study and not simply for addressing the task of including TK.

Traditional knowledge is often a sensitive issue as there are many issues surrounding TK such as intellectual property, specific use of information and misuse of information. Many First Nation communities are taking a proactive approach regarding participation within development projects in order to ensure that their rights and privileges are respected and are developing TK protocols. This seminar will aim to examine the role TK plays within the environmental assessment process.

The Struggle to Find a Balance: Pikangikum First Nation and the Whitefeather Forest Initiative

R. Michael O'Flaherty
Natural Resources Institute, University of Manitoba

The elders of Pikangikum First Nation, located in northwestern Ontario, have been central in guiding the Whitefeather Forest Initiative, a land-based community economic renewal and resource stewardship initiative that seeks to develop economic opportunities for Pikangikum youth through resource-based tribal enterprises including, in particular, commercial forestry. Mobilising Pikangikum indigenous knowledge has been an important part of ensuring Pikangikum elders' guidance is made more meaningful in the First Nation's joint planning efforts with the Ontario Ministry of Natural Resources.

While both the First Nation and the provincial government have engaged in novel approaches to working together, encouraging in itself after fifty years of substantial misunderstanding and conflict, the two planning partners are not always able to bridge the cultural divide that separates them. The content and intention of two very different knowledge systems, one indigenous and the other scientific, are shared across cultural barriers during key junctures in the process of coming together to engage in dialogue and decision-making. The partner responsible for shaping the institutional/cultural nature of those key junctures also shapes, wittingly or not, which knowledge tradition will dominate the exchange. These issues of how knowledge is shared and put to use in the Whitefeather Forest Initiative are discussed with reference to six years of experience in multi-disciplinary research and land-use planning activities.

Respect and Reciprocity: Engaging in Discussions with Indigenous People About Traditional Knowledge

Lorrilee McGregor, M.A.
Whitefish River First Nation

While the practices and ways of life of Indigenous peoples have existed for thousands of years, the concept of traditional knowledge was only introduced by academics in the early 1980s. Most Indigenous peoples were not too concerned with academic exercises around defining and documenting traditional knowledge until issues of commercialization and bioprospecting came to their attention. Of particular concern to Indigenous peoples is the lack of equitable involvement in decision-making when traditional knowledge is being sought, as well as ownership, control, access and possession of traditional knowledge. In response, Indigenous groups have developed research protocols and policies to protect traditional knowledge. Furthermore, a number of traditional knowledge initiatives have been initiated by Indigenous groups in Ontario. Support for the protection of traditional knowledge can be found within international agreements such as the World Intellectual Property Organization (WIPO), the Convention on Biological Diversity (CBD), the United Nations Declaration on the Rights of Aboriginal Peoples and the World Trade Organization (WTO).

Mining Community - Stakeholders Act
Hosts: Peter Beckett, CFEU, Laurentian University
Graeme Spiers, MIRARCO, Laurentian University

Franco Mariotti, Science North and Sarah Woods, Junction Creek Stewardship Committee
"The Junction Creek Clearwater Revival", Junction Creek Stewardship Committee, 10th Anniversary Film plus Commentary

Alan Lock, Graeme Spiers, Jennifer Hargreaves, Peter Beckett, Tamara Posadowski and Samantha Smith, Mirarco and Laurentian University
Can Tailings Produce Useful Biocrops?

Chris Wren, Mirarco, Laurentian University
The Sudbury Soils Study Ecological Risk Assessment

Stephen Monet, City of Greater Sudbury
Sudbury's New Biodiversity Action Plan

Fallon Kirkey and Peter Ryser. Laurentian University
Indication of Low-Level Metal Tolerance in Sudbury Red Maple (Acer rubrum)

The Junction Creek Clearwater Revival

Franco Mariotti and Sarah Woods
The Junction Creek Stewardship Committee Inc.

Junction Creek is a 23 kilometre waterway that runs through the heart of the City of Greater Sudbury. It has a long history of industrial and urban impacts. The Junction Creek Stewardship Committee (JCSC) is a non-profit, grass-roots organization that was formed in 1999 with a mission to "To restore all life to the Junction Creek ecosystem: native wildlife, insect and plant life, and to improve the quality of life for humans as well." It accomplishes this mission through restoration, education, research, and community involvement. The JCSC coordinates citizen participation in a number of re-greening efforts. Since 1999 it has coordinated the removal of 55 tons of garbage from the creek and banks, the planting of 25 000 trees and shrubs, and the release of 10 600 fingerling brook trout into the creek. It has involved almost 5000 volunteers, and administered their Bug Search program to 4600 students. Two years ago the JCSC began working on a film with the goal of producing a piece that would be both education and entertaining, and could be distributed to local schools to increase awareness. The 15 minute, $100 000 film premiered at Cinéfest Sudbury this September. The film details the industrial history of Sudbury and the resultant effects on Junction Creek. It also discusses the re-greening efforts within the watershed and their positive impact on stream health. The film highlights the role of the community in the re-greening of Sudbury, with the hope that young people will feel empowered and become engaged.

Historically, Junction Creek was treated as an urban ditch (A). Re-greening efforts in the Sudbury area, as well as tree planting along the creek (B), the removal of garbage (C), and educational programs (D) have improved the health of the creek.

Can Tailings Produce Useful Biocrops?

Alan S. Lock[1], Jennifer Hargreaves[1], Graeme A. Spiers[1, 2], Peter J. Beckett[1, 2,]
Tamara Posadowski[1, 2], Samantha Smith [1, 2]
[1]MIRARCO, [2]Department of Biology, Laurentian University

The project generates new feedstock sources to supply the biofuels industry and reclaims mine wastes, a priority for northern Ontario communities. Identification of crops and varieties that produce high quality biofuel that can be successfully cultivated in northern regions will help expand agriculture to previously unproductive and abandoned lands.

Large scale feasibility studies for the establishment of oil-seed and cellulose producing crops on mine tailings have been successfully conducted with the purpose of these crops to be used as feedstock to the biofuels industry. An acid sulphide Vale Inco tailings impoundment in Copper Cliff, Ontario and a Goldcorp Inc. near neutral pH goldmine tailings impoundment in Timmins, Ontario were both tested by amending half hectare plots to approximately 1 m thick with residual biosolids from the pulp and paper industry and growing canola and corn on these plots. At one site, full scale agricultural equipment was used to cultivate, seed and harvest the plots to prove the full scale feasibility of farming on these biosolids. The vegetation development, growth, yield, quality and composition were assessed to identify the best species that would maximize biomass development for feedstock to the biofuels industry and carbon credits for the mining industry. Corn and canola biomass development was assessed by following vegetation development, growth, yield, quality, and composition. Groundwater and tailings chemistry and biosolids degradation were monitored to identify potential deleterious impacts of degrading organic matter on tailings metal mobility. Preliminary hydrologic investigations using moisture sensor profiles elucidate potential conservation of water in amended plots.

Corn grown in St. Marys paper biosolids at the Vale Inco tailings in Copper Cliff, Ontario.

The Sudbury Soils Study Ecological Risk Assessment

[1]Christopher Wren, Ph.D., [2]Mary-Kate Gilbertson, and [3]Ruth Hull
[1]MIRARCO, Laurentian University, [2]AECOM, [3]Intrinsik Environmental Sciences Inc.

In 2001 Vale Inco and Xstrata Nickel (formerly Falconbridge) sponsored the Sudbury Soils Study. This included an extensive soil survey followed by a human health (HHRA) and ecological risk assessment (ERA). Seven Chemicals of Concern (COCs) were selected for the ERA: As, Cd, Co, Cu, Ni, Pb, and Se. The primary goals of the ERA were to:

- Evaluate the extent to which COC are preventing the recovery of regionally representative self-sustaining plant communities,
- Evaluate the risks of COCs to terrestrial wildlife populations, and
- Provide information to support activities related to the recovery of regionally representative, self-sustaining ecosystems.

It was determined that areas up to 35 km distant from the smelters are still significantly impacted by past smelter emissions and other historical activities. Much of this area is at risk to not recover without intervention. Direct risk to wildlife from the COC was not predicted, however, indirect impacts to habitat may be affecting some wildlife species. The results helped stimulate the City of Greater Sudbury and the two mining companies to initiate a Biodiversity Action Plan.

Existing Plant Community Conditions:

Undisturbed Reference Site Significantly impacted site Site with partial Recovery

Sudbury's New Biodiversity Action Plan

Stephen Monet
City of Greater Sudbury

For over 30 years, the City's Regreening Program has been liming, seeding and planting tree seedlings on Greater Sudbury's barren hills. These actions have not only improved the City 'look', but have also improved water quality by preventing erosion and helped create wildlife habitat where virtually none existed before. Although past regreening efforts have achieved significant improvements and recovery of lands affected by historical mining and smelting emissions, the Sudbury Soils Study's Ecological Risk Assessment confirmed that there is much more work to be done. Two main findings of the Risk Assessment were:

1. Terrestrial plant communities in the Greater Sudbury area have been and continue to be impacted by the Chemicals of Concern (i.e., arsenic, cadmium, cobalt, copper, lead, nickel, and selenium).
2. It is unlikely that the Chemicals of Concern originating from the smelter emissions are exerting a significant direct toxic effect on wildlife populations in the Greater Sudbury area. However, historic impacts of smelter emissions on plant communities may currently be affecting habitat quality and, therefore, may be having a continued influence on birds and mammals in the study area.

Regreening is the first step in ecological recovery. It brings back a green cover allowing stands of trees to grow on former barren hills. But the biodiversity (diversity of plant and animal species and the communities they create) is still low. Actions are needed to help self-sustaining forests and all their inhabitants thrive on Sudbury's hills.

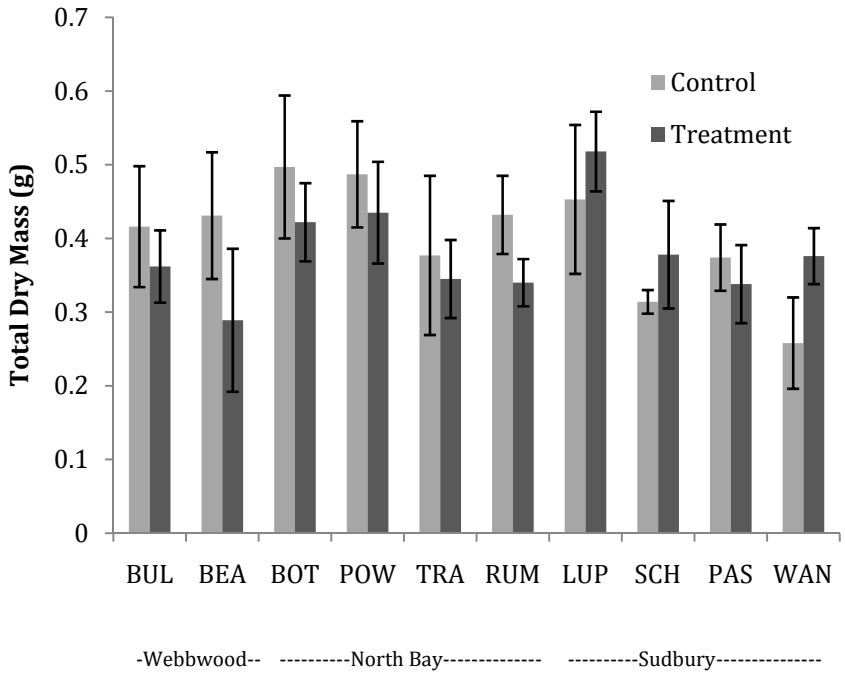
An Ecological Risk Management Framework was prepared outlining actions required to address the risks identified by the risk assessment. A key element of the Framework is the development of a Biodiversity Action Plan for Greater Sudbury that defines the vision and prioritized goals for biodiversity recovery.

A Draft Biodiversity Action Plan has been developed in a cooperative and collaborative effort under the leadership of the City of Greater Sudbury's Environmental Planning Initiatives Section. Oversight was provided by VETAC, City Council's regreening advisory panel. Development of the plan involved members of the community, university researchers, biodiversity stakeholder groups and funding partners.

Indication of Low-level Metal Tolerance in Sudbury Red Maple (*Acer rubrum*)

Fallon Kirkey and Peter Ryser
Department of Biology, Laurentian University

Red Maple (*Acer rubrum*) is commonly found in metal contaminated areas in Sudbury. Metal-tolerance is known to be induced by exposure to metals fast, within one or two generations, but the known cases are mostly herbaceous species. We investigated whether the tree red maple would have developed such a tolerance after a century of metal contamination in Sudbury area. To test for an inherited tolerance, a pot experiment was conducted using harvested seeds from parent trees in contaminated (Sudbury) and non-contaminated (North Bay and Webbwood) areas to screen for potential tolerant ecotypes in several populations. The results show that at low-level metal contamination (2% slag-sand mixture) seedlings of maple populations from Sudbury populations develop a significantly higher biomass than in the controls (sand only) compared to the opposite effect found in seeds collected from non-contaminated origins, indicating the development of a low-level tolerance.



Total Dry Mass of Red Maple (*Acer rubrum*), control and 2%-slag treatment, for Sudbury (contaminated) and Non-Sudbury (non-contaminated) populations (+/- S.E.).

*STUDENT POSTER

Community and Sectoral Response to Climate Change Impacts
Host: Al Douglas, MIRARCO

David Pearson, Co-Chair of Ontario's Expert Panel on Climate Change Adaptation
Climate Impacts and Adaptation in the Far North of Ontario – Change Like No One Has Seen Before?

Neil Comer, Environment Canada
Climate Change Models, Verification and Ensembles – An Ontario Focus

Al Douglas, MIRARCO
Climate Change in Northern Ontario – Community Vulnerabilities and Risks?

Laurie Tucar, Ontario Centre for Climate Impacts and Adaptation Resources
North South Climate Change Network

Jason Prno, Trailhead Consulting
Climate Change and Canadian Mining: Opportunities for Adaptation

Greg Ross and Dan Waddell, OCCIAR –Mirarco
Great Lakes Water Levels in a Changing Climate: Vulnerabilities of the Recreational Boating Sector

Climate Impacts and Adaptation in the Far North of Ontario – Change Like No One Has Seen Before?

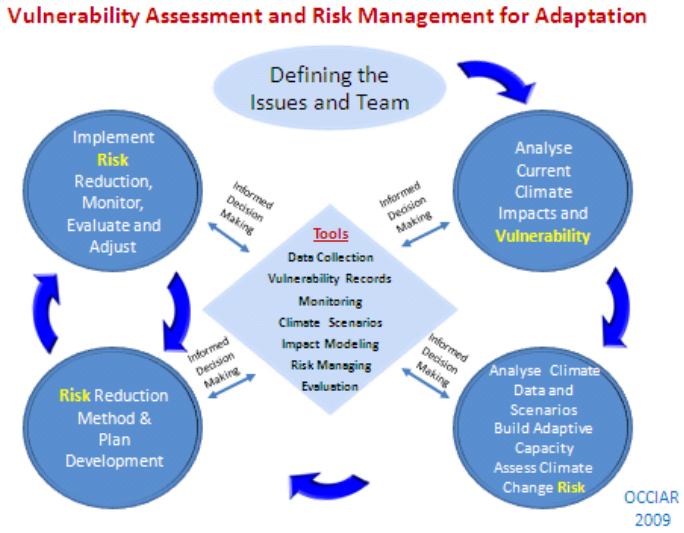
David Pearson
Ontario's Expert Panel on Climate Change Adaptation

Observations show that climate is changing more rapidly and more severely than suggested even as recently as 2007 by the Intergovernmental Panel on Climate Change. Current projections for the Far North of Ontario in 2050 developed by the Canadian Climate Change Scenarios Network strongly suggest more severe change in the Far North than anywhere else in Ontario. Winter temperature and precipitation projections are especially disturbing. A winter season shorter by several weeks along with considerably more snow implies an earlier and more voluminous Spring run-off causing more frequent and severe flooding in communities, as well as winter transportation issues and less reliable ice cover on Hudson Bay. Systematic analysis of climate change vulnerability involving traditional community knowledge, and the assessment of risk to Far Northern communities in the light of the best available projections, are prerequisites for pro-active as opposed to reactive adaptation in land use planning, infrastructure development, and resource extraction.

Weather events that are currently exceptional and extreme become more frequent as seasonal and annual averages shift. More monitoring is necessary to better understand the likely trends of extreme events accompanying rapid climate change in the Far North.

Included in the impacts from projected temperature and soil moisture changes are highly significant potential shifts in the contribution of cold climate peatlands in storing carbon. Potential warming feedbacks in the carbon cycle in the Far North and possible strategies for hindering those feedbacks or protecting carbon storage capacity are further and immediate challenges.

The backdrop of rapid climate change in a vulnerable environment will require on-going consideration of science at all scales in the Far North, from communities to watersheds and ecozones.



Climate Change Models, Verification and Ensembles – An Ontario Focus

Neil Comer, Ph.D.
Adaptation and Impacts Research Division (AIRD), Environment Canada

AIRD is strongly involved in the provision of relevant and practical information on climate change for Ontario and all of Canada's regions. Given the number of models (both Global-GCM and Regional-RCM), and emission scenarios available for consideration, there is no shortage of possible future projections of our climate. The wealth of information available can be overwhelming, and sound information, advice, application, interpretation, analysis of the results, and their uncertainties is required. The Canadian Climate Change Scenarios Network (CCCSN.CA) has become a major source for climate change information, with traffic approaching 2 million visits for this year and increasing. Within the multi-partner CCCSN, training sessions for end-users on model background information and their validation, and projections, have been held across Canada with more planned.

Validation results of climate change models against historical climate data (both observed station data and gridded continuous datasets), have shown there can be large biases with some models (too cold historically, too warm, too wet, too dry). Clearly some models do better than others. Validation is complicated in northern Ontario, however, by the limited availability of long-term meteorological observations for large areas of the province. In these areas, gridded datasets interpolated from nearby stations are our only option.

Recent journal articles have shown that the use of a single or small subset of models for climate change projections is unwise, with preference for an 'ensemble approach' which is expected to produce the best likely estimate. This is not surprising, since one might erroneously select a single model with significant historical bias, and/or a model with extreme projections for the future (far too high or too low). The ensemble mean projection produces an all-model value which weights all models equally. Each GCM is regridded to a common grid resolution and then analysed. The ensemble technique has the advantage of allowing for at least a basic measure of spatial model uncertainty (i.e. where is there high versus low model agreement). As part of CCCSN, 'Ensemble Scenarios for Canada, 2009' will soon be released, providing end-users with ensemble information for practical application. The information is provided at a national and regional scale for the 2050s (2041-2070) future time period. Not unlike other regions, the greatest temperature increase is projected for the winter season and for more northerly portions of the province (up to 6ºC). Similarly, precipitation from the ensemble projection is also expected to generally increase (except for summer), with the greatest increase to the north (up to 30%). The patterns found within Ontario are similar for both the GCM and RCM ensembles, with greatest differences in areas proximal to the Great Lakes and Hudson Bay due to the increased spatial scale available from the RCM. Results of this work in Ontario will be highlighted.

Climate Change in Northern Ontario – Community Vulnerabilities and Risks?

Al Douglas
Climate Change Adaptation, MIRARCO

As greenhouse gas concentrations continue to rise around the globe, changing weather and climate conditions are posing new challenges and risks to communities in Ontario. The economies of many northern Ontario communities are based on natural resources, thus climatic threats to biophysical systems will require attention and action in terms of adaptive planning. This proactive thinking and planning will ensure that communities in northern Ontario are prepared for the negative effects of climate change and are well positioned to capitalize on any advantages that may arise. Furthermore, communities must consider climate change when developing community plans. For example, economic development and strategic planning must recognize the significance of a low carbon future, reduce their dependence on fossil fuels and embrace a shift to sources of renewable energy.

This presentation will give an overview of the state of climate change planning in northern Ontario highlighting key challenges and concerns. Methods of improving adaptive capacity in northern Ontario communities and ongoing adaptation efforts will also be presented along with some of the methods available to aid and facilitate community adaptation planning.

The North South Climate Change Network

Laurie Tucar[1] and Thea Dickinson[2]
[1]Ontario Centre for Climate Impacts and Adaptation Resources, [2]Clean Air Partnership

The **North South Climate Change Network (NSCCN)** is a collaboration between the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) at MIRARCO-Laurentian University in Sudbury and the Clean Air Partnership (CAP) in the City of Toronto. This project has been made possible through a grant from the Ontario Trillium Foundation's Future Fund, which was created to enhance the future of Ontario's communities.

The NSCCN is striving to improve the province's knowledge of, and preparedness for climate change. Through the creation of partnerships with stakeholder groups, the network will foster a learning environment where participants within Ontario will learn about climate change impacts, share strategies and solutions.

The NSCCN aspires to transform the piecemeal nature of climate change response planning in Ontario by identifying common strategies, sharing regional progress and updating the group on best practices and other activities. By identifying participants' common climate change goals, the NSCCN intends to enhance existing, and foster new relationships with a variety of stakeholder groups.

The presentation will summarize the results of a Climate Change Needs Assessment Survey involving various sectors throughout Ontario. It will also include a short interactive demonstration of the network's extranet site, which is used by members for online interaction such as discussions calendars and document posting.

Climate Change and Canadian Mining: Opportunities for Adaptation

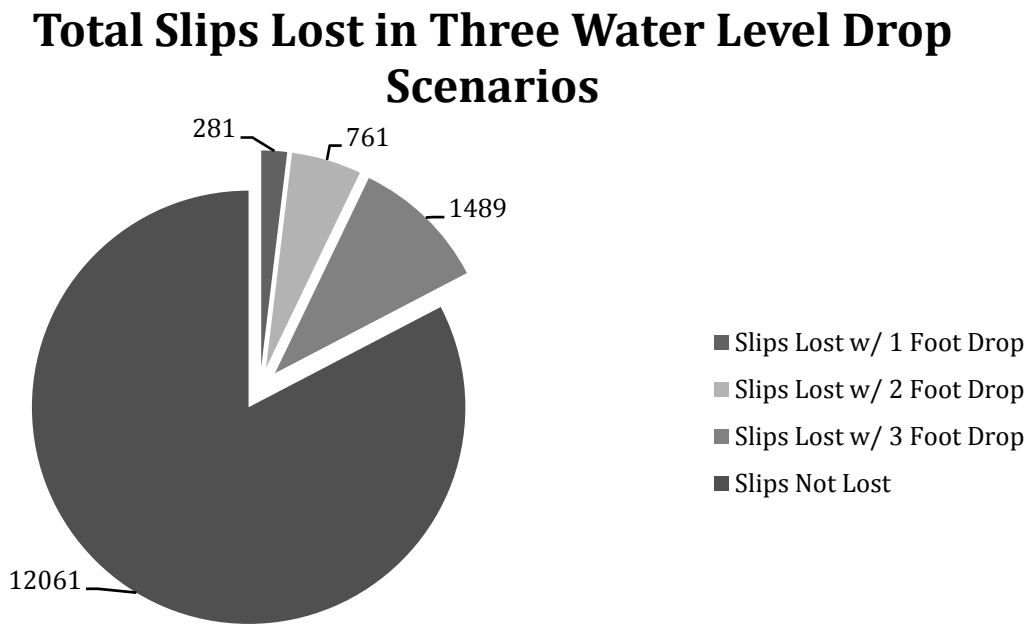
Jason Prno[1], Tristan Pearce[2], James Ford[2], and Frank Duerden[3]
[1]Trailhead Consulting, [2]ArcticNorth Consulting, [3]Frank Duerden Consulting

The scientific evidence that climate change is occurring is overwhelming. Increases in temperature, more extreme weather events, changes in precipitation, and altered weather patterns have been documented across Canada and these changes are projected to continue in the future with implications for business, industry, and communities. For the mining sector, climate change is a pressing environmental threat and a significant business risk. This presentation reports on the results of a two year, Canada-wide research project that assessed the vulnerability of Canadian mining operations to climate change. It draws on a series of case studies from Ontario, Yukon, Northwest Territories, Saskatchewan, Quebec, and Labrador, two industry practitioner surveys, and a review of the scientific and trade journal literature. Results indicate that mining operations across Canada are already being impacted by climate events with the distinctive fingerprint of climate change; these events are also expected to become more intense and frequent in the future. Those regions depending on transportation networks that are sensitive to climatic conditions (especially in northern Canada) are particularly susceptible. Other key findings are discussed, as are potential adaptation actions, and research and policy needs for the future.

Great Lakes Water Levels in a Changing Climate: Vulnerabilities of the Recreational Boating Sector

Greg Ross and Dan Waddell
Ontario Center for Climate Impacts and Adaptation Research at MIRARCO

In the Great Lakes basin, human activities are closely intertwined with the water levels of the Great Lakes. To assess the vulnerability of the recreational boating industry, research and survey work were carried out by two researchers in ten sample areas around the Great Lakes, surveying 88 marinas. Depth measurements were completed at 9457 wet slips to assess the regional and sector-wide capacity of the marinas to accommodate boats under hypothetical fluctuations in water levels. In addition, 77 marina operators were interviewed in order to assess how fluctuations in water levels had affected their marinas in the past, adaptations they had undertaken in response, as well as current adaptive capacity and threshold vulnerabilities in light of the same hypothetical water level fluctuations. An economic valuation will be attributed to the different fluctuation scenarios using the slip loss results as well as the information expressed in the interviews. These results will be used to identify potential improvements to the Lake Superior outflow regulation plans as part the International Upper Great Lakes Study (IUGLS), enacted by the International Joint Commission (the bi-national committee responsible for cooperative governance of the Great Lakes).



Climate Change and Multiple Stressors
Host: Bill Keller, CFEU Laurentian University

Jules M. Blais, Adam Houben, Todd French, Linda E. Kimpe, Michael Pisaric, Joshua Thienpont, and John P. Smol, University of Ottawa, Queen's University, and Carleton University
The Impact of Thawing Permafrost on Lakes of the Mackenzie Delta

Shelley Arnott, Jon Sweetman, Michael Pedruski, Celia Symons, Queen's University, Parks Canada, McGill University
Potential Climate Impacts on Lakes in Wapusk National Park

Andrew Paterson, Kathleen Rühland, Crystal Hyatt, John Smol, Bev Clark, Anna DeSellas, Kathryn Hargan and Peter Dillon, Dorset Environmental Science Centre, Ontario Ministry of the Environment, Queen's University, AECOM Canada Ltd., Trent University
Evidence of Recent Environmental and Climatic Change in the Lake of the Woods, Ontario

K.M. Rühland, A.M. Paterson , K. Hargan , A. Jenkin , N. Michelutti , B.J. Clark , and J.P.Smol
Queen's University, Ontario Ministry of the Environment, Trent University, and AECOM
Diatom Community Responses to Recent Warming and Other Stressors in the Lake of the Woods and Beyond

Michelle Palmer and Norman Yan, York University
Climate and Morphometry Drive Asynchronous Temporal Patterns in Lake Thermal Dynamics and Oxygen Content

Somers, K.M., C.L. Sarrazin-Delay and W. Keller
Ontario Ministry of the Environment, Laurentian University, and Cooperative Freshwater Ecology Unit
Using Redundancy Analysis to Quantify the Cumulative Effects of Multiple Stressors

Shannon MacPhee, Bill Keller, and Shelley Arnott, Cooperative Freshwater Ecology Unit, Laurentian University, Queen's University
Lake Thermal Regime and Crustacean Zooplankton Community Structure

Bill Keller, Laurentian University
Limnology in Ontario's Far North: An Introduction

The Impact of Thawing Permafrost on Lakes of the Mackenzie Delta

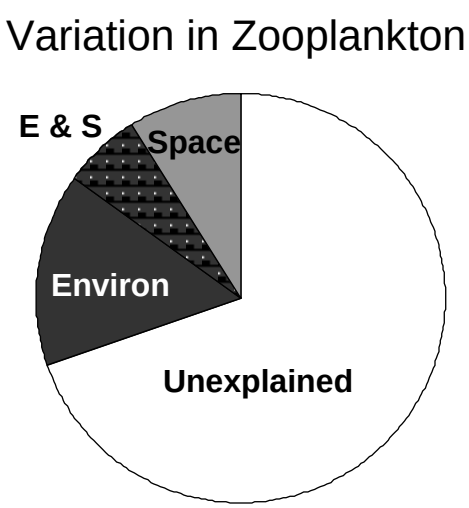
Jules M. Blais[1], Adam Houben[1], Todd French[2], Linda E. Kimpe[1], Michael Pisaric[3], Joshua Thienpont[2], and John P. Smol[2]
[1]Department of Biology, University of Ottawa, [2]Department of Biology, Queen's University, [3]Carleton University

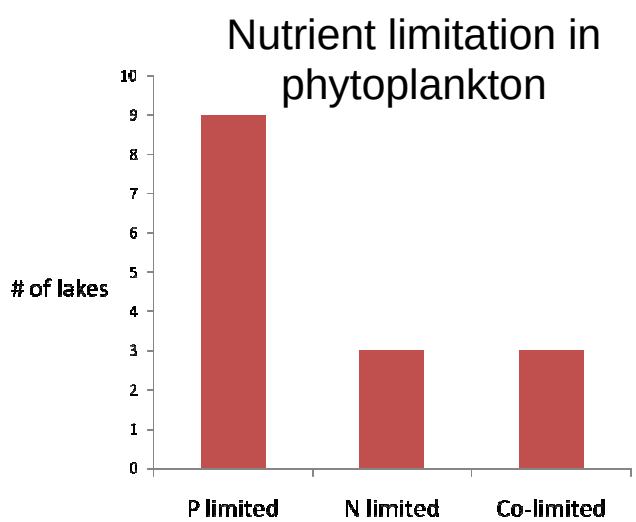
Total permafrost in the Northern Hemisphere currently occupies an area of 26 million km^2, and by 2100, this area is expected to decrease by 19-35%. In the Mackenzie Delta, NWT, temperatures are projected to rise by 4 to 5°C in the next 50 years, and thawing permafrost will be particularly severe. Despite these drastic and rapid changes projected for the cryosphere in the coming decades, remarkably little is known about the geochemical and biological consequences of thawing permafrost. We are testing the hypothesis that the presence of retrogressive thaw slumps in the Mackenzie Delta (north of Inuvik, NWT) is affecting nutrients (total and dissolved N and P), persistent organic pollutants, metal concentrations, and phytoplankton community assemblages in small tundra lakes. Preliminary results from 2009 indicate that dissolved organic carbon, total phosphorus, soluble reactive phosphorus, and total mercury were lower in lakes with retrogressive thaw slumps than reference lakes, possibly due to deeper water infiltration through clay-rich tundra soils. In addition, we are tracking changes in the lake's biota over time using fossil diatoms in lake sediment cores. Striking changes in diatom assemblages over time may be linked to past changes in melting permafrost. Future studies will investigate the effect of thaw slumps on microbial transformations of mercury, the transfer of persistent organic pollutants to surface waters, and limnological responses to the changing permafrost status.

Potential Climate Impacts on Lakes in Wapusk National Park

Shelley Arnott[1], Jon Sweetman[2], Michael Pedruski[3], and Celia Symons[1]
[1]Queen's University, [2]Parks Canada, [3]McGill University

Climate change is expected to have large impacts on northern regions over then next few decades. This may be especially true in subarctic regions where thawing permafrost is expected to have result in changes in landscape hydrology and the cycling of nutrients and organic matter. The response of biota (herbivores and primary producers) 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 climate change, we assessed potential local (e.g., water chemistry) and regional (e.g., dispersal) factors influencing plankton communities in Wapusk National Park, near Churchill, Manitoba. Low dispersal limitation (i.e., high dispersal) would suggest that these systems are adaptable to changing environmental conditions through the immigration of new species. In addition, we conducted nutrient enrichment bioassays on a subset of 21 lakes to assess nutrient limitation in the phytoplankton communities. This allows us to predict how future changes in nutrient concentrations might affect phytoplankton biomass and community composition. We found that local factors (e.g., pH and nutrient concentrations) and dispersal limitation were important drivers of zooplankton community composition. This suggests that species lost as a result of changing environmental conditions, may not be readily colonized from the regional species pool. Our nutrient bioassays revealed that 60% of our study lakes were phosphorus-limited, 20% were nitrogen-limited, and 20% were co-limited by nitrogen and phosphorus. Together, these results suggest that future climate change will likely have large impacts on plankton communities in the subarctic.



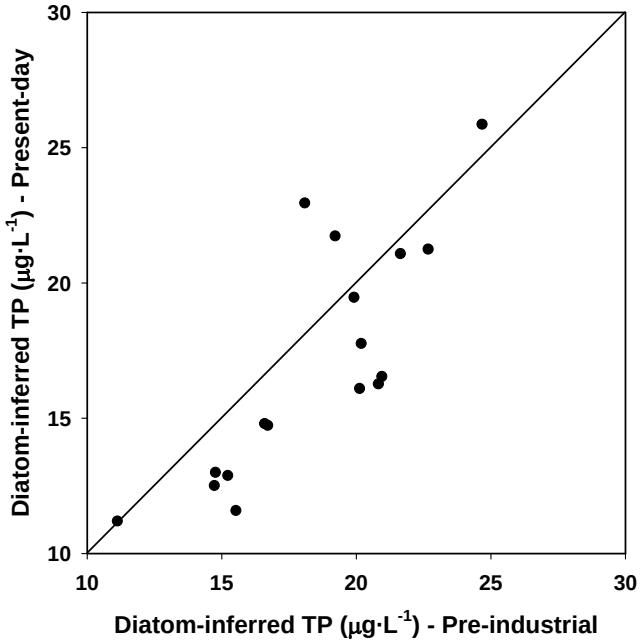


Explained variation in zooplankton communities in 92 lakes and number of lakes with nutrient limitation in 15-lake experiment.

Evidence of Recent Environmental and Climatic Change in the Lake of the Woods, Ontario

Andrew Paterson[1], Kathleen Rühland[2], Crystal Hyatt[2], John Smol[2], Bev Clark[1,3], Anna DeSellas[1], Kathryn Hargan[4] and Peter Dillon[4]
[1]Dorset Environmental Science Centre, Ontario Ministry of the Environment, [2]Department of Biology, Queen's University, [3]AECOM Canada Ltd., [4]Environmental and Resource Studies, Trent University

The Lake of the Woods (LOW) is an international waterbody spanning the Canadian provinces of Ontario and Manitoba, and the U.S. state of Minnesota. Although algal blooms have been reported in southern regions of the LOW since the early 1800's, there is a perception that water quality in northern regions of the lake is deteriorating, leading to an increase in algal bloom severity in recent years. New evidence suggests that recent climatic warming may also play a role. In the absence of long-term historical data, however, these trends are difficult to verify. Furthermore, due to its size and hydrological complexity, the water quality of the LOW is highly variable and difficult to assess. We present monitoring and paleolimnological data to assess spatial and temporal trends in water quality in the LOW. In this presentation, we focus specifically on total phosphorus (TP), showing that concentrations are highly variable, both spatially and seasonally throughout the lake. Using models developed from diatom assemblages in lake sediment cores, we reconstruct total phosphorus concentrations through time at multiple sites, showing that inferred-TP concentrations are similar today to what they were in the pre-industrial time period. Finally, we synthesize existing data into a nutrient budget quantifying the relative sources of total phosphorus to the LOW.



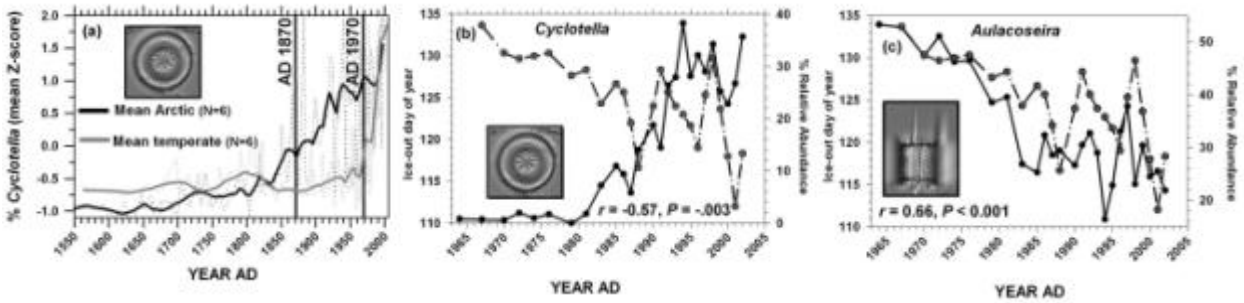
A comparison of diatom-inferred total phosphorus concentrations in present-day and pre-industrial time periods at 17 sites in the Lake of the Woods.

Diatom Community Responses to Recent Warming and Other Stressors in the Lake of the Woods and Beyond

K.M. Rühland[1], A.M. Paterson [2], K. Hargan [3], A. Jenkin [1], N. Michelutti [1], B.J. Clark [4], and J.P.Smol [1]
[1]PEARL, Queen's University, [2]Ontario Ministry of the Environment, Dorset, [3]Trent University, [4] AECOM, Bracebridge

The effects of recent temperature increases on freshwater ecosystems will likely be masked in regions subjected to a variety of different environmental stressors. Although the nature and magnitude of climate-driven responses vary among freshwater systems, a warmer climate will undoubtedly affect important lake-water properties and thus biota in numerous and often surprising ways. Despite differences among lake settings and characteristics, regional climate drivers may result in a general coherent biotic response among lakes within biogeographic regions. In this study we assess the ecological and environmental implications of diatom assemblage compositional changes recorded over the last ca. 200 years with particular reference to the Lake of the Woods (LOW), Ontario, Canada. Comparisons between a reference site and impact sites will provide a better understanding into the effects that multiple stressors (particularly, total phosphorus (TP), hydro management practices and recent warming) have had on the lake's biota. Trends in air temperature, lake ice cover, and lacustrine primary production will be compared to overall patterns of diatom assemblage compositional changes analysed from ^{210}Pb-dated sediment cores retrieved from each LOW site.

A sharp increase in the relative abundances of planktonic *Cyclotella* taxa and a concurrent decline in thickly-silicified *Aulacoseira* taxa starting ca. 1980 at the reference site are consistent with the warmest decades on record. These taxon-specific diatom trends will allow for insights into the mechanisms underlying diatom community reorganizations (e.g. responses due to changes in water column properties, habitat structure and quality etc.). The recent taxon-specific shifts that we report from LOW reference site will be placed into a larger geographical context through comparisons to over 200 diatom-based paleolimnological records from non-enriched, non-acidified lakes throughout the Northern Hemisphere including Arctic Canada.



Taxon-specific diatom shifts related to warming trends in Northern Hemisphere lakes.

Climate and Morphometry Drive Asynchronous Temporal Patterns in Lake Thermal Dynamics and Oxygen Content between Two Long-Term Study Areas

Michelle Palmer and Norman Yan
York University

Lake physical properties such as temperature and oxygen content are extremely dynamic and are regulated by both lake-specific characteristics and regional processes. Climate in particular plays a large role in determining lake physics and there has been growing interest in lake response to potential climate change. However, climatic forcing differs between lake districts and lake-specific characteristics and localized stressors modulate response to regional climate patterns, making it difficult to predict lake response to climate change. To assess the relative influence of climate in spatially distal lake districts and the regulatory impact of local characteristics, we examined patterns in physical properties for 12 lakes sampled from 1981 to 2005. Seven lakes were located near Dorset, Ontario, and five lakes were in the Trout Lake Area (TLA) in northern Wisconsin, USA. Our specific objectives were (1) to determine whether physical lake properties have changed monotonically over time, (2) to assess the temporal coherence of lakes within a region, (3) to examine relationships between physical lake properties and climate variables, and (4) to detect lake-specific characteristics regulating response to regional climate. Our objective was not to suggest climate change between historical and contemporary time periods but rather to identify links between climate and lake morphometry and physics, thus providing insight as to lake response to future climate change scenarios.

Over the 25 year study period, lakes became warmer and more stable with slightly shallower thermoclines and stratification zones. In TLA lakes, the metalimnion also increased in thickness and mean oxygen content. However, all changes were seasonally dependent and only occurred in the early fall in Dorset and throughout the fall in TLA. Although Dorset lakes were consistently less temporally coherent than TLA lakes, coherence within a region was generally high suggesting lake physical properties were responding to regional drivers. Fall warming of lakes was predominately related to temporal increases in fall air temperature for both Dorset and TLA lakes (32 and 64% of variance explained, respectively). Thermocline and stratification depths were related to spring and summer air temperature (~10%) but as these predictors did not change monotonically over time, they likely do not account for temporal changes in depth. In the Dorset lakes, shallower thermocline and stratification depths were most strongly related to temporal increases in dissolved organic carbon (25%), an indirect effect of climate change and reductions in acidification. None of the climate variables examined (including seasonal and yearly precipitation, wind and climate indexes) accounted for shallower depths and increased metalimnetic oxygen in the TLA lakes but high coherence indicated regional control. Lake depth regulated lake response to fall warming in both Dorset and TLA (~15% and 50%, respectively) while lake area regulated response to DOC in Dorset (~25%). In summary, physical properties of lakes in Dorset and TLA exhibit temporally coherent trends which are likely, at least in part, due to climate drivers. Climatic forcing varies not only between lake districts but also between spatially proximate lakes, partially due to the regulating role of lake morphometry.

Using Redundancy Analysis to Quantify the Cumulative Effects of Multiple Stressors

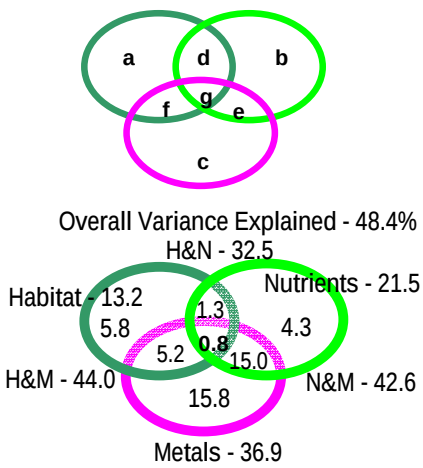
Somers, K.M.[1], C.L. Sarrazin-Delay[2] and W. Keller[2]
[1]Ontario Ministry of the Environment, Dorset Environmental Science Centre
[2]Laurentian University, Cooperative Freshwater Ecology Unit

Most cumulative effects assessments are descriptive rather than quantitative. Statistical tools to tease apart the cumulative effects of multiple stressors are generally lacking. Recent interest in multiple stressors has underscored the need for tools to quantitatively evaluate the cumulative effects of two-or-more stressors. Using data based on metal mine and pulp-mill environmental effects assessments, we utilize multivariate multiple regression, or redundancy analysis, to partition the cumulative effects of two stressors. Variation in four benthic community metrics is partitioned among natural habitat features and the separate effects of mining and pulp-mill effluents. This approach quantifies the individual and combined effects of different stressors that potentially affect the benthic community, providing a quantitative tool for cumulative effects assessment, and permitting an objective evaluation of the separate impacts of multiple stressors.

A - Variance Allocation Table

Analysis		Variance	%	Allocation	Number
PCA		4.00	100.00		
RDA - all 9 variables		1.9	48.4	abcdefg	1
RDA - Habitat		0.5	13.2	a+d+f+g	2
RDA - Nutrients		0.9	21.5	b+e+d+g	3
RDA - Metals		1.5	36.9	c+e+f+g	4
RDA - H & N		1.3	32.5	abdefg	5
RDA - N & M		1.7	42.6	bcdefg	6
RDA - M & H		1.8	44.0	acdefg	7
		Unique (%)	Shared (%)		
a	1-6	5.8	7.1	a+d	7-4
b	1-7	4.3	11.0	a+f	5-3
c	1-5	15.8	5.7	b+d	6-4
d	(a+d)-a	1.3	19.4	b+e	5-2
e	(b+e)-b	15.0	30.9	c+e	7-2
f	(c+f)-c	5.2	21.1	c+f	6-3
g		0.8	1-(a+d)-(b+e)-(c+f)		

B - Venn Diagrams

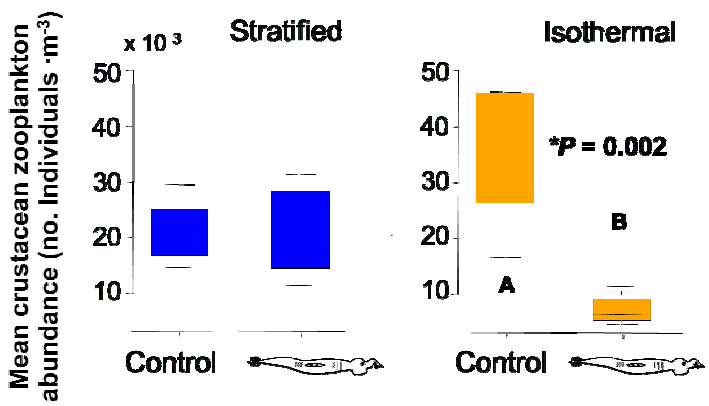


Example calculations in a variance allocation table (A) and associated Venn diagrams (B) illustrating how variance in the four benthic metrics is partitioned by habitat, nutrient and metal variables.

Lake Thermal Regime and Crustacean Zooplankton Community Structure

Shannon MacPhee[1], Bill Keller[1], and Shelley Arnott[2]
[1]Cooperative Freshwater Ecology Unit, Laurentian University, [2]Biology Department, Queen's University

Crustacean zooplankton are an important component of the freshwater food-web and an essential link in the transfer of energy between primary producers and higher trophic levels such as fish. Zooplankton community structure in many Boreal Shield lakes will be affected both directly and indirectly by altered thermal regime as a result of climate warming. Changes in thermal regime have occurred in recent years in several Sudbury-area lakes. Biological data from one long-term study system reveal some potential consequences of changes in lake thermal regime for zooplankton community structure. In Swan Lake, direct thermal effects have resulted in reductions in both individual and community-level zooplankton body size in warm years over a 16-yr study period. Increases in the relative abundance of smaller-bodied, faster reproducing parthenogenic species in warm versus cool years are associated with subsequent declines in the relative abundance of more long-lived, cool-water species. Differences in zooplankton abundance between warm and cool conditions are not evident at the annual scale, likely because smaller clutch sizes and reduced survival due to thermal stress are compensated by faster reproduction times and a longer growing season at higher temperatures. Additionally, experimental evidence suggests that indirect effects on zooplankton community structure may occur as a result of altered predation rates under various thermal regimes predicted with future climate warming. These observed changes in zooplankton community structure may have important implications for ecosystem functioning and the transfer of nutrients and energy to higher trophic levels in thousands of recovering-acidified Boreal Shield lakes affected by climate change. Plans for future work include examining the effects of altered lake thermal structure at the seasonal scale using long-term monitoring data from several Sudbury- and Dorset-area lakes.



The effects of *Chaoborus* predation on total crustacean zooplankton abundance (no. individuals per m^3) in stratified and isothermal experimental enclosures.

Limnology in Ontario's Far North: An Introduction

Bill Keller
Cooperative Freshwater Ecology Unit, Laurentian University

Information on the state and basic nature of aquatic ecosystems in Ontario's far north is very limited. However, wise management of aquatic resources depends on good information; we need to understand the systems we are trying protect. Northern ecosystems are potentially very vulnerable to various stressors including resource extraction (mining, forestry) and large-scale anthropogenic influences like climate change. To understand how these systems might 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.

Developing and conducting the science programs needed to study aquatic systems in the far north will be an ongoing process. As an early step, in 2009 studies were initiated on lakes in the area of Hawley Lake (54° 30′, 84° 37′) near the Hudson Bay Coast. Surveys were completed on eleven of these northern lakes, to provide information, for some or all of them, on:

1) Basic biology (zooplankton, phytoplankton, littoral invertebrates) and water chemistry (including mercury concentrations).
2) Mercury concentrations in fish.
3) Lake sediment cores to allow reconstruction of past conditions through examination of diatom remains and mercury analyses.

The lakes sampled included Aquatuk, Hawley, Kinushseo, North Raft, North Wahagami, Oppinagau, Oppinagau East, Raft, Spruce, Sutton, and Warchesku. This study involves scientists from Laurentian University, Queens University, the University of Ottawa, and the Ontario Ministries of the Environment and Natural Resources. All information generated from this work will be made available to stakeholders involved with managing and protecting water resources in Ontario's far north.

Poster Abstracts

Poster Abstracts

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

Babin-Fenske, J. J. and M. Anand STUDENT POSTER
Adding Infest to Injury: Why Stressed Forests May Have Longer Forest Tent Caterpillar Outbreaks

Bergeron, K. and D. Campbell STUDENT POSTER
Creation of a Functional Soil for Native Plants at the DeBeers Victor Diamond Mine near Attawapiskat, Ontario

Cooper, S., L. Hare and P. G. C. Campbell STUDENT POSTER
Modeling Cd Uptake From Water and Food by the Freshwater Bivalve *Pyganodon grandis*

Cousins, C., P.J. Beckett and G.A. Spiers STUDENT POSTER
Organic Matter Degradation and Metal Uptake of Shallow Paper Sludge Covers over Gold Mine Tailings

Devlin, J. and S. Finkelstein
Applications of Paleolimnology in Ecosystem Monitoring for Sirmilik National Park: Developing Indicators of Ecological Integrity STUDENT POSTER

Dirszowsky, R.W., K.A. McLandress and S.B. Foster
Human Impact, Industrial Pollution and Landscape Change Inferred from Sedimentation Patterns at Kelly Lake, Sudbury, Ontario

Fortier, J. L. and C. C. Wilson STUDENT POSTER
Inbreeding Depression and Genetic Rescue in the Endangered Aurora Trout (*Salvelinus fontinalis timagamiensis*): Assessment and Conservation Options

Garrah, K and D. Campbell STUDENT POSTER
Establishing Reference Conditions for the Restoration of Created Barren Uplands in the Hudson Bay Lowland

Inglis, C., S. Arnott, and G. Pyle STUDENT POSTER
The Effect of Copper on *Daphnia pulicaria* Kairomone Response

Kirkey, F. and P. Ryser STUDENT POSTER
Indication of Low-Level Metal Tolerance in Sudbury Red Maple (*Acer rubrum*)
[See Mining Community - Stakeholders Act, Concurrent Session Oct. 29, 2009 for abstract]

Koski, P. and G.A.Spiers STUDENT POSTER
Atmospheric Particulate Matter within the Sudbury Footprint

Laurin, C. and D. Campbell STUDENT POSTER
Identification of Suitable Plant Species for Restoring Disturbed and New Uplands in the Subarctic: A Functional Ecology Approach

Leithead, M., M. Anand and L. Silva STUDENT POSTER
Treefall Gaps Allow Northward Tree Migration in the Temperate – Boreal Forest Ecozone

Linley, R. D., J. Shead and N. Yan
Identifying Temperature and Calcium Thresholds for *Daphnia* sp. in a Multiple Stressor Scenarios

Luek, A., G. Morgan, and C. Ramcharan STUDENT POSTER
Limited Benthic Invertebrate Availability Hampers the Recovery of Lakes Recovering from Acidification and Metal Contamination

Martin, M., J. Litzgus, and J.Hamr STUDENT POSTER
Spatial Behaviour and Habitat use by Elk (*Cervus elaphus*) in Response to Highway Construction and Interprovincial Relocation

Monette, N., G. A. Spiers, and P. J. Beckett STUDENT POSTER
Anthropogenic Succession on Gold Tailings Amended with Organic Residual Materials from the Pulp and Paper Industry

Monette, N., G. A. Spiers, and P. J. Beckett
Metals in Plant Tissues and Organic Residual Materials Overlying Gold Tailings in Timmins, Ontario

Morris, D.W., A. Moenting, A. Dupuch, S.B. Ale, and D.E. Moore
Predicting Changes in Arctic Small Mammal Communities from Global Warming

Posadowski, T., G.A. Spiers, P.J. Beckett, J. Hargreaves, and A. Lock STUDENT POSTER
The Growth of Biofuel Crops on Amended Mine Tailings

Quinlan, R., M. Paterson, D. Schindler, and J. Smol
Inferring Thermal Regime in Shallow Boreal Lakes

Rusak, J.A., B. Edwards, R.A. Reid, D.A. Jackson and K.M. Somers.
Temporal and Spatial Predictors of Crayfish Declines in South-Central Ontario

Schoenau, S., G.Spiers, and S. Ritz STUDENT POSTER
Bioavailability of Copper and Nickel Contaminants Extracted from Soil in the Gastrointestinal Tract

Smith, S., G. Spiers, P. Beckett, J. Hargreaves, and A. Lock STUDENT POSTER
Adaptation of Engineered Organic Tailings Cover as a Biofuel Crop Growth Medium

Smith, Z.M., S.P. Glaholt, J.K. Colbourne, and J.R. Shaw STUDENT POSTER
Evidence for Genetic Adaptation to Metals in Sudbury Area *Daphnia pulex* Populations by Gene Duplication

Szkokan-Emilson, E.J. STUDENT POSTER
Healthy Lands Promote Healthy Waters: Terrigenous Organic Matter as a Subsidy for Recovering Consumer Communities in a Sudbury Lake

Watelet, A., C. Chevrier, A.L. James, and B. Kamber
Geography of Waterbodies in the Airport Glaciofluvial System – Upper Junction Creek Valley Glaciolacustrine Sandy Deposits: Rare Earth Elements and Water Stable Isotopic Signatures – Preliminary results

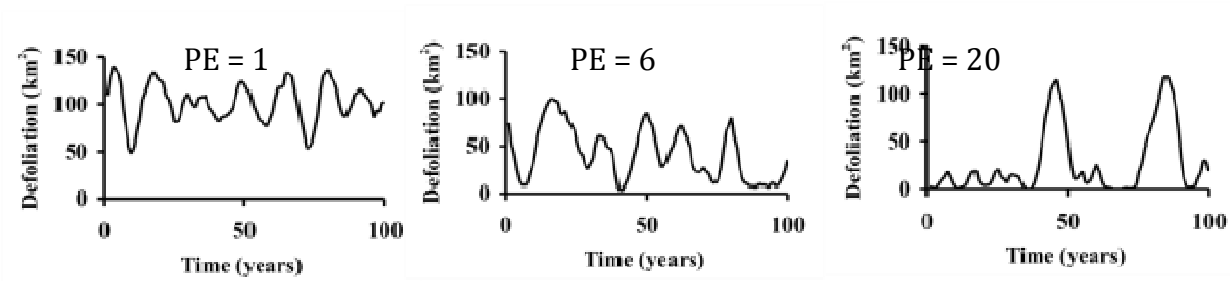
Williamson, A., J. Abedin, C. Cousins, T. Maki, and G. Spiers STUDENT POSTER
Are Microbes Efficient at Economic Metal Extraction from Ores?

White, M.S., M.A. Xenopoulos, R.A. Metcalfe, and K.M. Somers
The OWLLS Study - Water Level Fluctuation of Ontario Lakes: Character, Ecological Influence and Impacts of Regulation

Adding Infest to Injury: Why Stressed Forests May Have Longer Forest Tent Caterpillar Outbreaks

Jennifer J. Babin-Fenske [1] and Madhur Anand[2]
[1]Department of Biology, Laurentian University, [2]Department of Environmental Biology, University of Guelph

The region of Sudbury, Ontario, Canada has longer forest tent caterpillar (*Malacosoma disstria* Hübner) outbreaks than surrounding areas. This may be a result of the historic pollution of the region and may also hinder restoration efforts by reducing the quality and survivability of the struggling plant community. Here we developed a spatially-explicity individual-based host-parasitoid model to study how stress may affect population fluctuations by altering the fecundity, dispersal, mortality and feeding behaviour of the forest tent caterpillar (FTC) and its parasitoids. Theoretical and empirical ranges for parameters were established using literature and over 50 years of population data of the FTC from Ontario, Canada. The theoretical parasitoid was based on the primary source of mortality for the FTC; the pupal parasitoid sarcophagid fly *Arachnidomyia aldrichi* Parker. Preliminary results of this simulation model suggest that if stress decreases the parasitoid fecundity (e.g., pollution reducing fitness) or searching efficiency (e.g., pollution interfering with chemical cues), there will be an increase the mean overall defoliation, but it will not change the frequency of outbreaks. This suggests that stressed forests will have more severe and widespread defoliation from these insects than surrounding unaffected forests. Stressors on a forest ecosystem may include pollution, climate change, urbanization and other natural or anthropogenic disturbances or events. As these disturbance may increase in frequency over time through changes in human population size, the global climate and sources of contamination, understanding how they may affect the outbreak cycle of a forest defoliator can aid in planning strategies to reduce the detrimental effects of this insect.



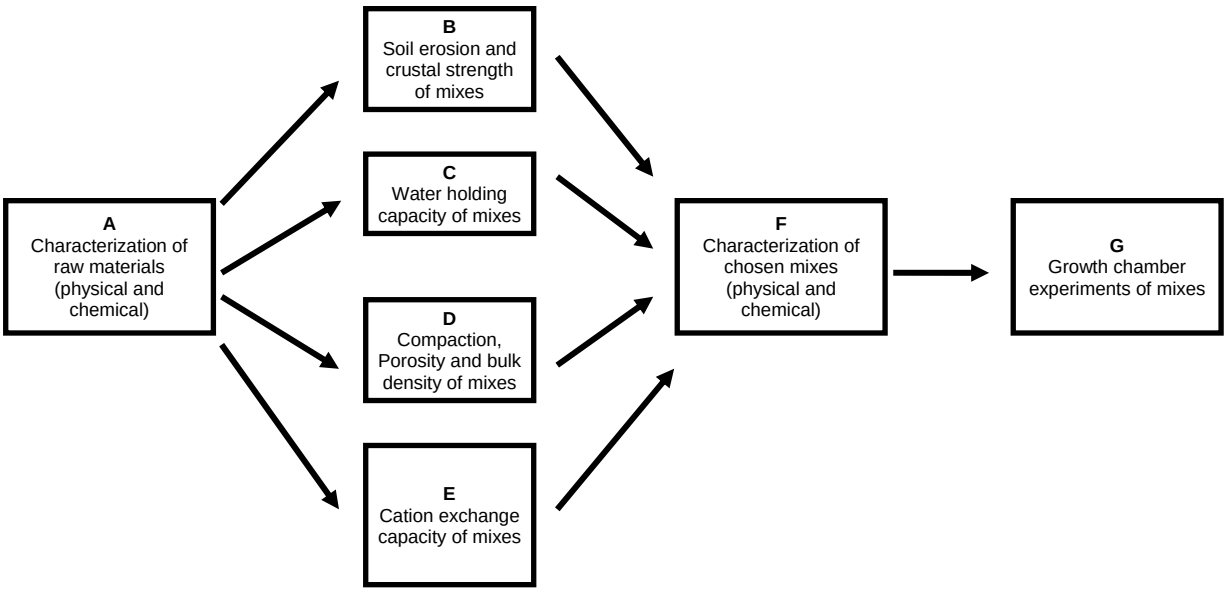
Changes in defoliation from modifying parasitoid searching efficiency (PE) within the simulation model.

*STUDENT POSTER

Creation of a Functional Soil for Native Plants at the DeBeers Victor Diamond Mine near Attawapiskat, Ontario

Kathryn Bergeron and Daniel Campbell
Biology Department, Laurentian University

Mineral exploration and mining are increasing in the Hudson Bay Lowland (HBL) and elsewhere in the subarctic. The Victor diamond mine is the first mine in the HBL and began production in 2008. The open pit will produce a series of deposits that must be reclaimed, including peat (1.8 million m^3), silt and clay overburden (11. 3 million m^3), processed kimberlite (10.4 Mt) and waste rock (26 Mt). Our goal is to determine whether these ingredients can be used to make functional soil mixes, able to support native vegetation. Initial chemical and textural analysis will be used to suggest broad suitable mixes. The crustal strength and erosivity of mixes will then be tested in parallel with studies of compaction, water holding capacity and cation exchange capacity of mixes. Good candidate mixes will then be tested further in greenhouse trials using paper birch (*Betula papyrifera)* and native grass species. Successful mixes should be able to be used to reclaim mining wastes elsewhere in the Hudson Bay Lowland and in other subarctic and arctic regions.



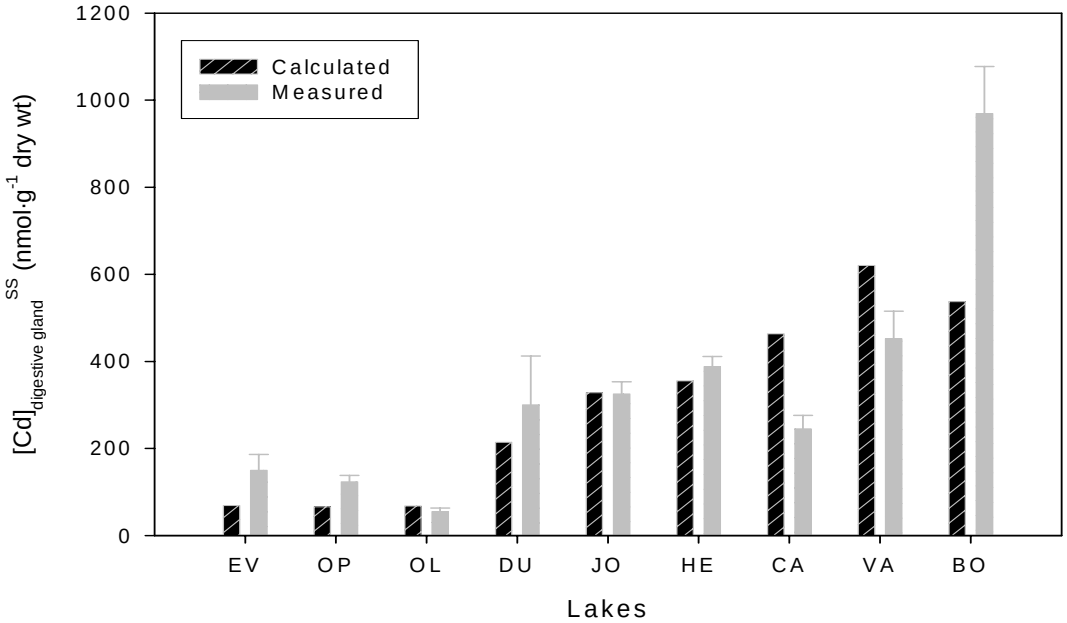
Procedure for analysing and creation of growing substrate suitable for plant growth.

*STUDENT POSTER

Modeling Cd Uptake from Water and Food by the Freshwater Bivalve *Pyganodon grandis*

Sophie Cooper, Landis Hare and Peter G. C. Campbell
INRS-Eau, Terre et Environnement, Université du Québec

This study describes laboratory experiments designed to assess the potential of the bivalve, *Pyganodon grandis*, as a biomonitor of cadmium (Cd) contamination in freshwater environments. Bivalves were either exposed to dissolved Cd or fed Cd-contaminated algae (*Pseudokirchneriella subcapitata*) during short-term experiments. The fate of Cd within *P. grandis* was dependent on its uptake route: Cd accumulated largely in the gills after an aqueous exposure, or in the digestive gland after a dietary exposure. Bivalve filtration rates were shown to have a significant influence on Cd accumulation from the dissolved phase as $[Cd]_{gills}$ generally increased as bivalve filtration rates increased. These results were used to parameterize a bioaccumulation model to estimate the relative importance of water and food as sources of Cd for this bivalve. Model simulations showed that water was the main source of Cd for *P. grandis* in the laboratory. The model was then used to predict steady state Cd concentrations in the gills and digestive gland of native bivalves and the simulations were compared with data obtained from earlier field studies on *P. grandis*. The model tended to underestimate Cd concentrations in *P. grandis* gills, especially in Ca-poor lakes, whereas it adequately predicted Cd concentrations in the digestive gland. The results of our study will facilitate the interpretation of spatial and temporal variations in Cd concentrations in free-living *P. grandis* and simplify its use as a metal biomonitor.



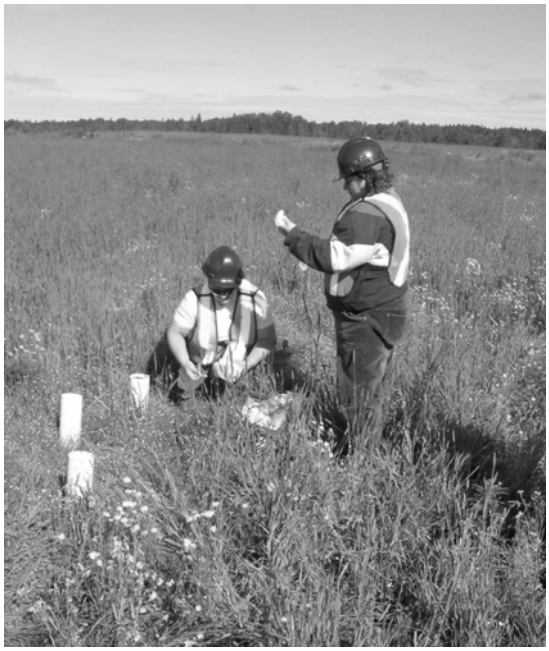
Comparison between calculated steady-state digestive gland Cd concentrations (± SD) in *P. grandis* exposed to waterborne + diet-borne Cd and those measured in the digestive glands of bivalves collected from lakes in the Rouyn-Noranda region.

*STUDENT POSTER

Organic Matter Degradation and Metal Uptake of Shallow Paper Sludge Covers over Gold Mine Tailings

C. Cousins[1], P.J. Beckett[2] and G.A. Spiers[1]
[1]Centre for Environmental Monitoring, MIRARCO, Laurentian University
[2]Department of Biology, Laurentian University

Mine drainage prevention is of primary concern to the global mining community. Over the last decade there has been significant interest in using industrial by-products as artificial soil covers to sequester mine-drainage-producing wastes. This study addresses two major concerns regarding the use of paper sludge amendments in mine reclamation strategies: the long-term stability of the paper sludge covers and the potential movement of metals from the mine waste into the overlying paper sludge. These questions were examined through sampling and analysis of a six-year sequence of shallow paper sludge amendments applied to gold mine waste in Timmins, Ontario, Canada. Over the time scale of the study, the paper sludge amendments showed no significant change in the relative abundance of their major carbon constituents: cellulose, hemi-cellulose, and lignin. However, increasing carbon-to-nitrogen ratios after three years may signal the beginnings of early-stage decomposition. A digestion method, coupled with inductively coupled plasma-mass spectrometry analysis, was developed and successfully validated for the quantification of 20 elements of nutritional and environmental interest within the paper sludge amendments. Analytical data obtained using the developed method only revealed an upward flux for iron, manganese, copper, and nickel. Metal concentrations in the paper sludge amendment covers were compared to the Canadian Soil Quality Guidelines and with the exceptions of Cu, Ni, and Se all metals met the guidelines for industrial land use.



Sampling paper sludge covers applied over gold mine waste in Timmins, Ontario.
*STUDENT POSTER

Applications of Paleolimnology in Ecosystem Monitoring for Sirmilik National Park: Developing Indicators of Ecological Integrity

Jane Devlin and Sarah Finkelstein
Department of Geography, University of Toronto

In the remote High Arctic location of Sirmilik National Park (SNP), Canada, there is sparse information available on the freshwater lakes and streams and their ecological status. Potential impacts of changing climate and increasing populations of Snow Geese remain unknown, yet may have significant influence on the health of these ecosystems. Access to these sites for monitoring is logistically complicated and highly resource intensive. A three-part approach is taken for assessment of freshwater ecosystem health in two physiographically distinct regions of Sirmilik: (1) water chemistry analysis, (2) analysis of distribution and diversity of diatoms and benthic invertebrates, and (3) paleolimnological reconstructions from lake sediment cores of key environmental variables and ecological change prior to the Industrial Era. These approaches, paired with tailored monitoring protocols, provide the foundation for a successful long-term freshwater monitoring program for SNP.

Water chemistry data were analysed using a suite of 18 physical and nutrient variables and 8 major ions as variables. Principal components analysis reveals the most important water quality variables for chemical distinction of the sites as total nitrates, dissolved organic carbon and soluble reactive phosphates. PCA and cluster analyses show differences between the two regions of Qorbignaluk Headland (QB) and Bylot Island (BY) sites, with the QB sites showing less within-site variability than BY sites. ^{210}Pb radioisotope analyses concluded that sedimentation accumulation rates at the BY sites are approximately four times that of the QB sites.

Modern diatom assemblages were analysed for 15 BY sites, and 14 QB sites (including 6 BY stream sites and 2 QB stream sites). Diatom species richness is higher at the QB sites, where water is poorer in nutrients. *Staurosirella pinnata* and *Staurosira construens* var. *venter* are dominant species at the BY sites and are rare (<1% abundance) at the QB sites; QB lakes have a more diverse presence of *Eunotia* species compared to BY, which is expected given their ultra-oligotrophic status.

Investigations for obtaining a more robust biomonitoring approach pair benthic macroinvertebrate assemblages with modern diatom data. Invertebrate assemblages are dominated by Chironomidae and Oligochaeta, while other taxonomic groups present include Collembola, Hydrachnida, Simuliidae and Plecoptera. Differences between the two regions are apparent in the assemblages, however, identification to genus or species level is recommended for obtaining clearer species-environment relationships. No justification was found for sampling with a 200-μm mesh in place of the 400-μm mesh called for in standard protocols used in lower latitudes.

*STUDENT POSTER

Human Impact, Industrial Pollution and Landscape Change Inferred from Sedimentation Patterns at Kelly Lake, Sudbury, Ontario

Randy W. Dirszowsky, Kirsi A. McLandress and Simon B. Foster
Department of Geography, Laurentian University

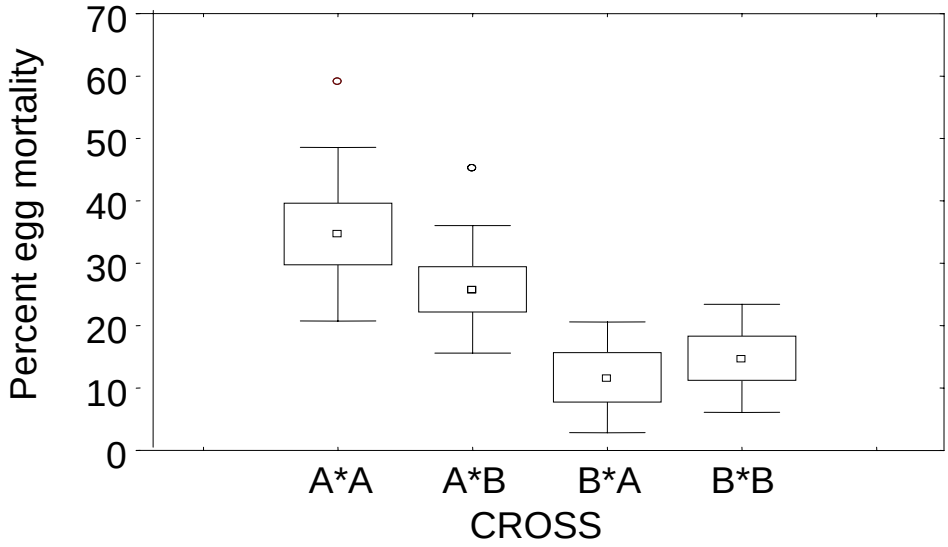
Kelly Lake, centrally located within the City of Greater Sudbury, receives runoff and sediment from a 210 km^2 catchment and provides evidence of landscape change related to human settlement, urbanization and industrial/mining activity during the last century and a half. Eight piston cores ranging from ~60 cm to ~160 cm in length were recovered from the delta foreset area and main basin of Kelly Lake in autumn of 2007 and 2008. The longest cores document at least five distinct phases of sedimentation. Earliest deposited sediments consist of very fine-grained, regularly laminated (couplets << 0.1 cm) organic-rich materials thought to represent natural, pre-settlement accumulation. Three overlying sedimentary units consisting of coarser (silt) less organic material contain rhythmic lamination that becomes thicker and more variable upward (Unit II, 0.03-1.3 cm; Unit III, 0.06-0.7 cm; Unit IV, 0.21-4.31 cm). Extensive upland erosion associated with vegetation loss, and an increasingly flood-prone runoff regime are indicated. In contrast, a final massive, largely organic unit represents low energy accumulation related to the establishment of sewage treatment facilities and flood control structures in the watershed from the 1960's through 1980's.

Kelly Lake delta-top changes are interpreted from surface channel and floodplain morphology, riverbank exposures, hand auger data and (piston-percussion) sediment cores. Core samples were analyzed for industrial metal contamination using ICP-MS following aqua regia digestion. From air photo interpretation, it is evident that delta progradation has resulted in an approximate doubling of the delta-top floodplain area since 1928 AD. Vertical accretion facies associated with buried soils and forest remnants evident in outcrop reveal aggradation averaging at least 0.5 m across much of the delta floodplain (3.2×10^5 m^2). Elevated metal (Cu and Ni) concentrations (10-30 X background) confirm the link between industrial emissions (since ca. 1886 AD), landscape degradation and increased sediment yields, and suggest that sediment accumulation and contaminant redistribution may be ongoing though at a reduced rate. Creosote contamination associated with a facility operating upstream between 1921 AD and 1960 AD affects approximately 0.8×10^5 m^2 of the delta floodplain at depth (~30 to > 110 cm) in close proximity to Kelly Lake and lowermost Junction Creek, and is found in appreciable quantities in upper Unit IV and throughout Unit V of the more distal lake sediments.

Inbreeding Depression and Genetic Rescue in the Endangered Aurora Trout (*Salvelinus fontinalis timagamiensis*): Assessment and Conservation Options

Jenny Lynn Fortier[1] and Chris C. Wilson[2],
[1]Environmental and Life Sciences Graduate Program, Trent University, [2]Ontario Ministry of Natural Resources, Aquatic Research Section, Trent University,

The aurora trout (*Salvelinus fontinalis timagamiensis*), an endangered form of brook trout endemic to Temagami Ontario, was extirpated in the 1960's due to lake acidification. All aurora trout alive today are descended from nine founder individuals and decades of captive breeding. Genetic analyses have revealed that aurora trout have very little genetic diversity; likely indicating a limited ability to adapt to future environmental variation. To address concerns relating to potential inbreeding and reduced fitness owing to their lack of genetic diversity and population history, common-garden rearing experiments were conducted on aurora trout and wild-type brook trout to compare life history traits relating to reproductive and somatic fitness. Bidirectional mating crosses between aurora trout and wild-type brook trout were also conducted to determine whether facilitated gene flow (F1, F2 and backcross progeny) could mitigate reduced fitness, and determine whether 'genetic rescue' is recommended for aurora trout. Results of both studies show evidence of inbreeding depression in aurora trout (reduced survivorship, growth, egg quality and fecundity). It is concluded that aurora trout are extremely vulnerable to environmental changes and wild populations should continue to be thoroughly monitored. In the event of population decline genetic rescue via limited introgression with brook trout may be a viable option for restoring fitness and increasing the adaptive potential of aurora trout, however it is recommended that controlled comparative fitness studies be conducted in the wild first.



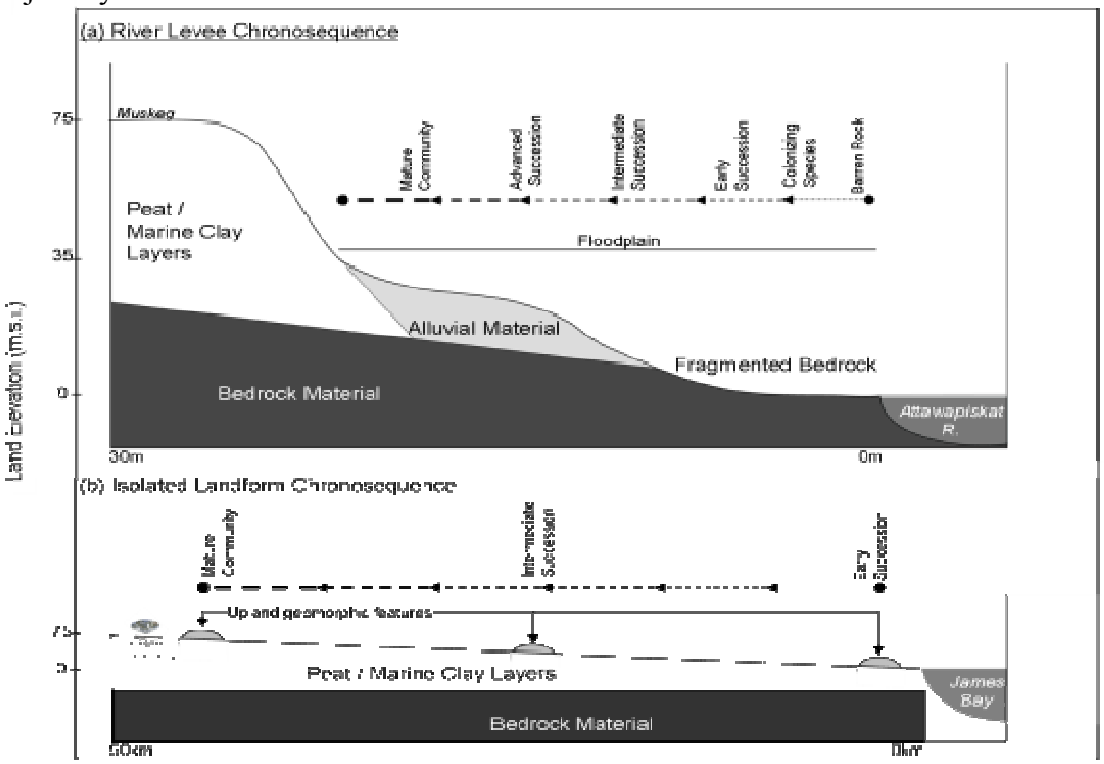
Percent egg mortality (from 0 days to 122 days of age) of F1 aurora, wild-type brook trout and hybrids of the two.

*STUDENT POSTER

Establishing Reference Conditions for the Restoration of Created Barren Uplands in the Hudson Bay Lowland

Katherine Garrah and Daniel Campbell
Biology Department, Laurentian University

Recent mining activity in the Hudson Bay Lowland is creating a need for the revegetation of created uplands. To do this effectively, we require an understanding of plant succession and soil-plant relationships on existing upland environments. However, little is known about relationships between plants and soils on natural uplands in the subarctic, or on the succession of vegetation on these natural uplands. My objective is to determine reference conditions for new anthropogenic uplands through examination of natural upland areas. Using 10 m x 10 m plots, I sampled key plant and soil ecosystem characteristics along well-drained river levee chronosequences local to De Beers Victor Mine (n=35). These shorelines provide examples of primary succession on uplands. I also examined early, intermediate and mature successional stages on isolated upland landforms (n=43) along a 90 km chronosequence of increasing elevation between James Bay and Victor Mine. Target parameters include soil physical and chemical characteristics, vegetation structure and cover, species richness and species composition. The variability determined will provide the potential flexibility in parameters for creating the novel ecosystems required. These reference conditions will provide restoration managers at subarctic latitudes a template of possible upland conditions and successional trajectory in similar environments.



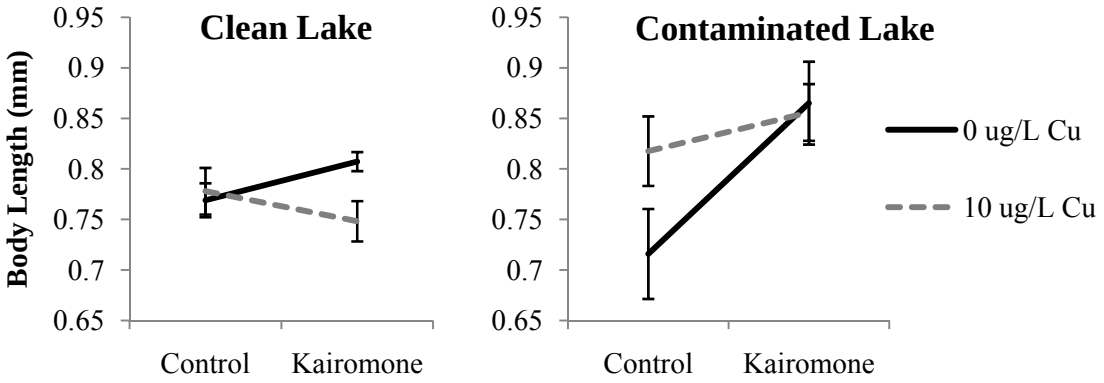
Diagrammatic representation of chronosequence studies (a) along river levees, (b) along a regional chronosequence of isolated upland features, such as eskers, beach ridges and bioherms. The dotted line represents maturing stages of succession.

*STUDENT POSTER

The Effect of Copper on *Daphnia pulicaria* Kairomone Response

Colleen Inglis[1], Shelley Arnott[1], and Greg Pyle[2]
[1]Queen's University, [2]Lakehead University

Kairomones are infochemicals that benefit a heterospecific receiver. *Chaoborus spp.* release a kairomone from their gut when feeding on *Daphnia* spp. *Daphnia* can respond to kairomone by shifting life history parameters or producing neonates with induced morphological defenses (e.g., neckteeth, enlarged bodies), which increases their probability of survival. When lab-cultured *Daphnia* are exposed to environmentally-relevant metal concentrations they do not induce a response to kairomone, making them more vulnerable to predation. Currently *Daphnia* can be found in metal-contaminated lakes in Sudbury, ON, therefore it is possible the extant populations have developed a tolerance to Cu as a result of natural, chronic metal exposure. An increased tolerance to Cu may enable these *Daphnia* populations to respond to kairomone even when exposed to Cu. We examined how multiple clones of *Daphnia pulicaria* obtained from lakes along a copper-contamination gradient responded to kairomone in the absence and presence of copper. Several clones from lakes in Sudbury, ON, and Dorset, ON, area were exposed to increasing environmentally-relevant copper concentrations and predator kairomone. Neonates were collected and measured to assess predator-induced morphological defenses and life history changes. Results from this study suggest that kairomone-mediated inducible responses and the effect of Cu on those responses vary among clones where some clones maintained the ability to respond to *Chaoborus* at environmentally-relevant Cu concentrations and others did not. There was no strong relationship between natural Cu exposure and increased Cu-tolerance. Most importantly responses were inhibited at concentrations much lower than predicted lethal concentrations, which most water quality criteria are based on.



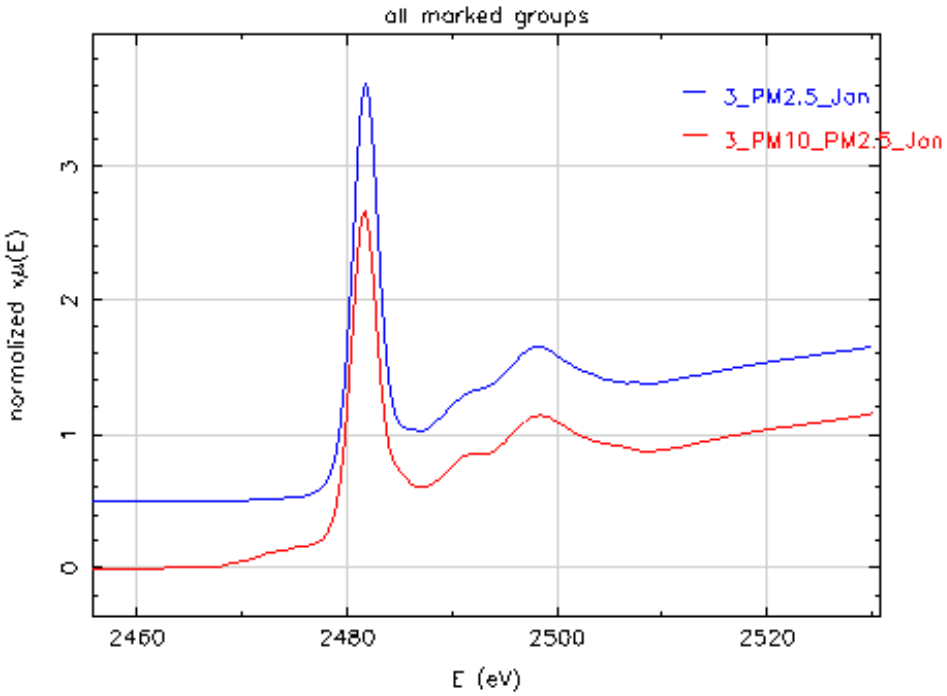
Comparison of the effect of Cu on neonate body length produced by clones from a clean and a contaminated lake

*STUDENT POSTER

Atmospheric Particulate Matter Within the Sudbury Footprint

Pamela Koski and Graeme A.Spiers
Centre for Environmental Monitoring/MIRARCO

Measuring exposure to coarse, fine and ultrafine dust and their association with metals in the air is important for health and ecosystem risk assessments. Therefore, determining the concentration in the different particle size fractions which may exist in the atmosphere is essential. The goal of this study was to investigate the concentration, particle size distribution and spatial dispersion of metals in total and fractioned airborne dust. Samples of airborne dust were collected at five different sites over a one year period in the Sudbury area, including one control site located downwind of the south-westerly most industrial emission source. Varying traffic densities and meteorological aspects such as prevailing wind directions were considered in selecting sampling sites. To account for spatial distribution and atmospheric transport of metals, sampling was performed simultaneously at all five sites. X-ray Fluorescence (XRF) was used to determine the total concentration of As, Co, Cr, Cu, Mn, Ni, Pb and Zn in airborne dust. Results from this analysis suggest that the more centrally located sites, within the city of Greater Sudbury, contained the most metals compared to the other sites and that most metals were more concentrated in the respirable size fraction, $PM_{2.5}$. Also, X-ray absorption near edge structure (XANES) was used to determine the S K-edge speciation in the PM_{10+}, PM_{10}-$PM_{2.5}$, and $PM_{2.5}$ size fractions, for three sites at the end and midpoint of the transect. This analysis revealed that atmospheric S is mostly in the form of sulphate.



XANES S k-edge spectrum revealing atmospheric sulphur in the form of sulphate.

*STUDENT POSTER

Identification of Suitable Plant Species for Restoring Disturbed and New Uplands in the Subarctic: A Functional Ecology Approach

Cory Laurin and Daniel Campbell
Department of Biology, Laurentian University

The use of local native plants is becoming a prerequisite for the restoration of disturbed lands. The De Beers Victor mine in the Hudson Bay Lowland is an open pit which will create new upland deposits on the landscape. These new uplands must be reclaimed with native species, but little is known on these plants. Our objective is to characterize the common species of upland vascular plants to select suitable candidate species to reclaim these new uplands and lead them towards successful revegetation. A total of 67 upland vascular plant species covering a range of vegetative forms were sampled with a minimum of three populations per species. A set of 16 easily-measured plant traits are being measured on each population to infer plant species responses and effects to ecosystem processes in the subarctic. These traits include canopy height, Raunkiaer life form, life span, leaf size, specific leaf area, leaf thickness, leaf toughness, leaf tissue pH, inrolling of lamina, woodiness, distance between ramets, shoot phenology, propagule mass, propagule mass/area, seed mass and seed shape. For each population, habitat characteristics were also measured, namely canopy cover and soil moisture regime, texture, pH and conductivity. Species will be classified into functional groups using multivariate analyses to determine species types (i.e. best dispersers, best colonizers). The protocols formulated through this study will be useful for the rehabilitation of the Victor site, but it will be useful to restore other mine sites and disturbed habitats in the subarctic.

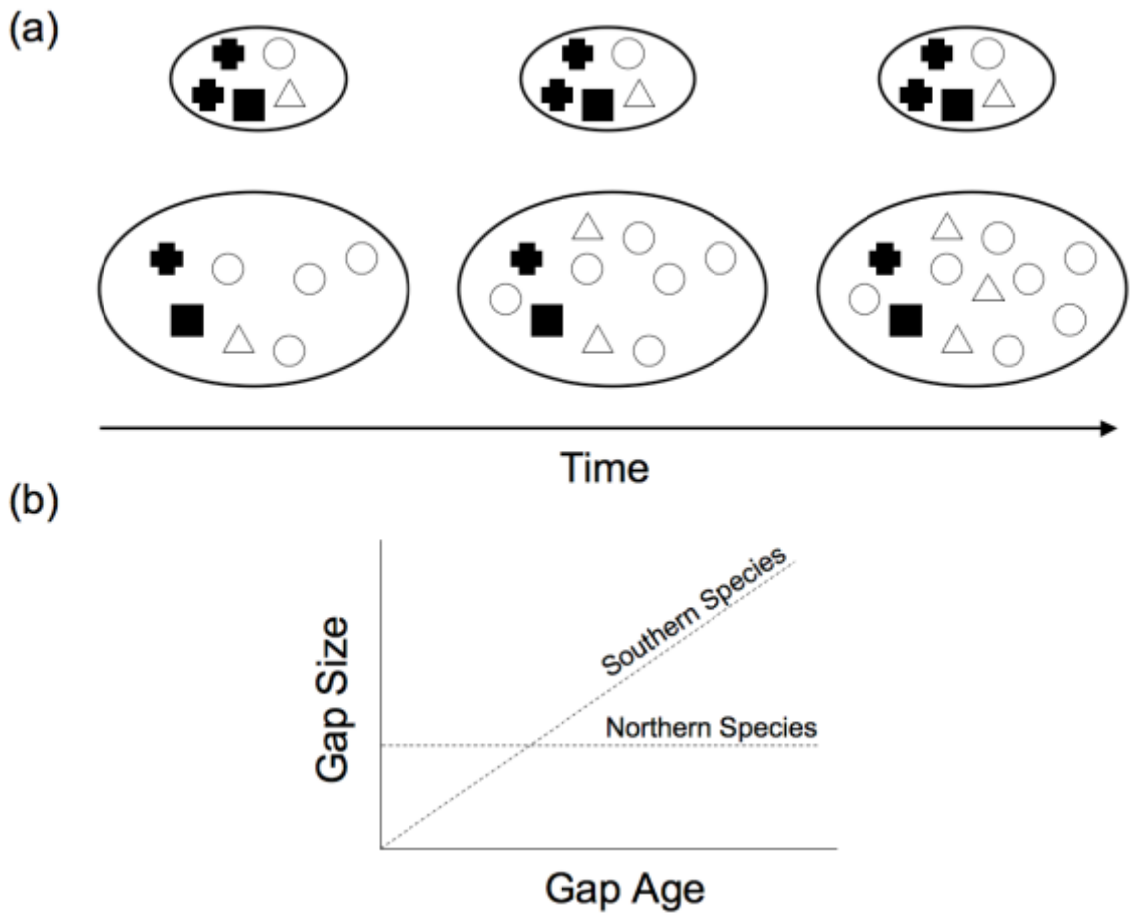
Map displaying the location of the De Beers Victor Diamond mine in Ontario Canada. The Victor Diamond mine is situated within the Hudson Bay Lowland (grey outlined area). The closest community to the Victor Diamond mine is Attawapiskat.

*STUDENT POSTER

Treefall Gaps Allow Northward Tree Migration in the Temperate – Boreal Forest Ecozone

Mark Leithead, Madhur Anand and Lucas Silva
School of Environmental Sciences, University of Guelph

In broad ecozones migrating forest species may use treefall gaps as opportunities to establish in otherwise competitively exclusive environments. We investigate gap dynamics of an old-growth red pine (*Pinus resinosa*) forest in the Great Lakes – St. Lawrence forest in Northern Ontario, Canada, a transition zone between temperate and boreal forest. Our results show that tree species that typically have more northern distributions, such as black spruce (*Picea mariana*), paper birch (*Betula papyrifera*) and red pine show no relationships with gap size or age; however southern temperate forests species, such as red maple (*Acer rubrum*), red oak (*Quercus rubra*) and white pine (*Pinus strobus*) occur more frequently in large, old gaps. Treefall gaps in this forest allow northward migration of trees, potentially acting as a mechanism for forest migration likely in response to recent changes in climate.



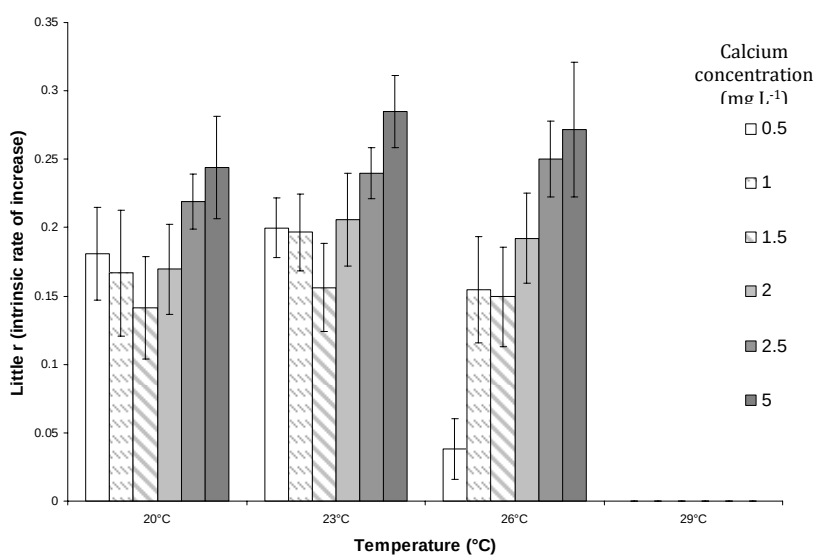
Conceptual diagram of effects of gap size and age on tree composition

*STUDENT POSTER

Identifying Temperature and Calcium Thresholds for *Daphnia* sp. in a Multiple Stressor Scenarios

R. Dallas Linley, Justin Shead and Norman Yan
York University and the Dorset Environmental Science Centre

There is a growing awareness that climate change and declining calcium (Ca) levels will adversely affect Canadian Shield lakes, but the potential interaction is unclear. We have determined that the reproductive capacity of *Daphia pulex* declines with declining calcium levels likely leading to sharp population crashes and potential extirpation when lake Ca levels fall below 1.5 mg/L. Climate change is an additional stress on *daphnia* populations, with changes in the timing of ice-out, thermal stratification and summer maximum temperatures all affecting zooplankton community composition. Predicting interactive effects of Ca decline with thermal change are compromised by the availability of appropriate lab studies. Most such research has employed *D. pulex,* a hard water, pond species and the assays were conducted in a modified hard water media. The results of this research may not be readily transferable to the soft water lakes of the Canadian shield, unless the identified thresholds are proven to be similar with soft water, lake-dwelling species assayed in soft water media. We investigated both thermal and low-Ca thresholds of three soft water, native *daphnia* species at 20, 23, 26, 29 □C, and calcium concentrations of 0.5, 1.0, 1.5, 2.0, 2.5, 5.0 mg L^{-1} both separately and in a multiple stressor lab scenarios. Increasing temperature improved the reproductive capacity of *daphnia* up to 26 ^{o}C but reproduction ceased or was severely impaired at 29 degrees. We confirmed the Ca results of earlier work, but with soft water lake species in soft water assays, i.e. reproduction declined with Ca decline with an approximate 1.5 mg L^{-1}threshold. Warming interacted with Ca decline in our assays. Implications of this work will be discussed in a broad context of northern lakes and possible futures scenarios.

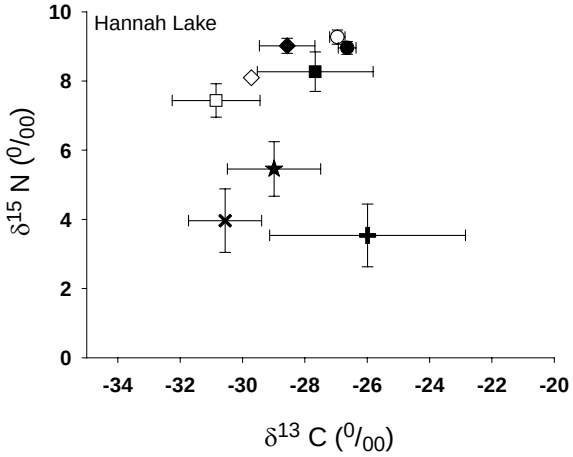


The intrinsic rate of natural increase of *Daphnia pulicaria* by temperature (□C) and calcium levels (mg L^{-1}) in a soft water media.

Limited Benthic Invertebrate Availability Hampers the Recovery of Lakes Recovering from Acidification and Metal Contamination

A. Luek[1], G. Morgan[2], and C. Ramcharan[1]
[1 1]Dept. of Biology, Laurentian University, [2]Cooperative Freshwater Ecology Unit, Laurentian University

Benthic invertebrates are strongly exploited by fish and form a crucial part in the food webs of freshwater lakes. In the Sudbury area, benthic invertebrates seem to have a reduced biomass and diversity, which may hamper biological recovery. This energetic bottleneck should be especially restricting in lakes with high levels of piscivory, within which yellow perch (*Perca flavescens*) primarily use the littoral zone. We studied perch in two lakes with low piscivore abundance and two with high piscivore abundance over a two year period. Additionally, in 2006 one of the high piscivore lakes was stocked with 184 smallmouth bass (*Micropterus dolomieu*). We measured perch use of pelagic and littoral habitats, determined diet and stable isotope signature, and compared these to resource availability (i.e., benthic invertebrate biomass). High piscivory reduced perch biomass and caused a shift in habitat use from the pelagic to the littoral that was reflected in the stable isotope value. There was little variation in perch carbon value in low piscivore lakes while in high piscivore lakes there was high variation and a greater use of littoral carbon sources. Chironomids were most abundant both in the environment and in littoral perch diets in all lakes. While total benthos abundance was similar in all lakes, larger benthic invertebrates (Odonata and Trichoptera) were more abundant in high piscivore lakes. A limited benthic community may hamper the development of a more diverse fish community when the arrival of piscivorus fish changes the population size structure and behavior of the perch but also affects the predation pressure on benthos.



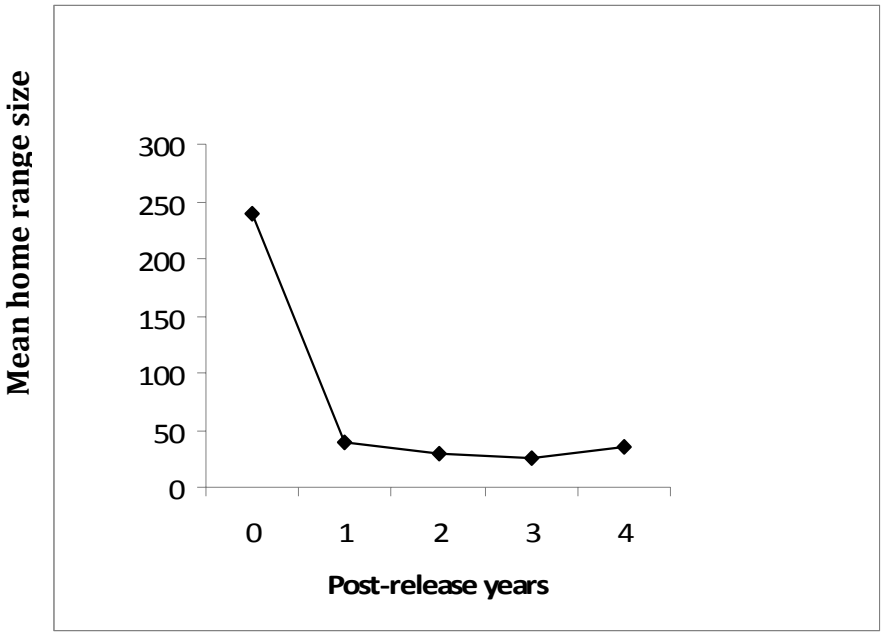
Stable carbon and nitrogen values for perch and their food sources in the manipulated Hannah Lake. Open symbols are pelagic, closed symbols are littoral. Round (2006), square (2007), and diamond (2008) symbols are perch values, x represents zooplankton, + represents benthic invertebrates, and star represents *Chaoborus* values.

*STUDENT POSTER

Spatial Behaviour and Habitat Use by Elk (*Cervus elaphus*) in Response to Highway Construction and Interprovincial Relocation

Michelle Martin, Jacqueline Litzgus, and Josef Hamr
Department of Biology, Laurentian University

Once native to Ontario, elk (*Cervus elaphus*) were extirpated in the 1800's due to over-harvesting and anthropogenic habitat alteration. In the 1950s an elk herd was established in the Burwash region, 30 km south of Sudbury, which was reduced to approximately 40 individuals by 1994. In the hope of establishing a sustainable population, elk were introduced from Alberta from 1998 to 2001, and the herd has been monitored since 1998 using radio telemetry. In January 2006, the four-laning of highway 69 began and has created disturbance that has altered the elk habitat. The objectives of this study are to analyze the spatial behaviour and habitat selection of Burwash elk in order to: 1) study acclimatization of the introduced elk, and 2) observe the effects of highway construction on the herd. After introduction, we predicted that elk would initially have large home ranges and large daily movements as they explored their new habitat. We expected this exploratory period to be followed by a 'leveling off' period (i.e., a reduction in home range size) indicating acclimatization. In addition, we expected changes in habitat selection and shifts in the locations of home ranges as elk settle into their new habitats. Preliminary results indicate that acclimatization occurs at 2.5 to 3 years post-release. We expect that highway construction will affect the elk, causing them to disperse over the surrounding areas to avoid the highway construction. The study can determine if this was due to physical destruction/fragmentation of habitat and/or emotional distress. This project provides a unique opportunity to study the effects of anthropogenic impacts and the effectiveness of reintroductions for restoring wild populations. This knowledge is essential for planning effective population management.

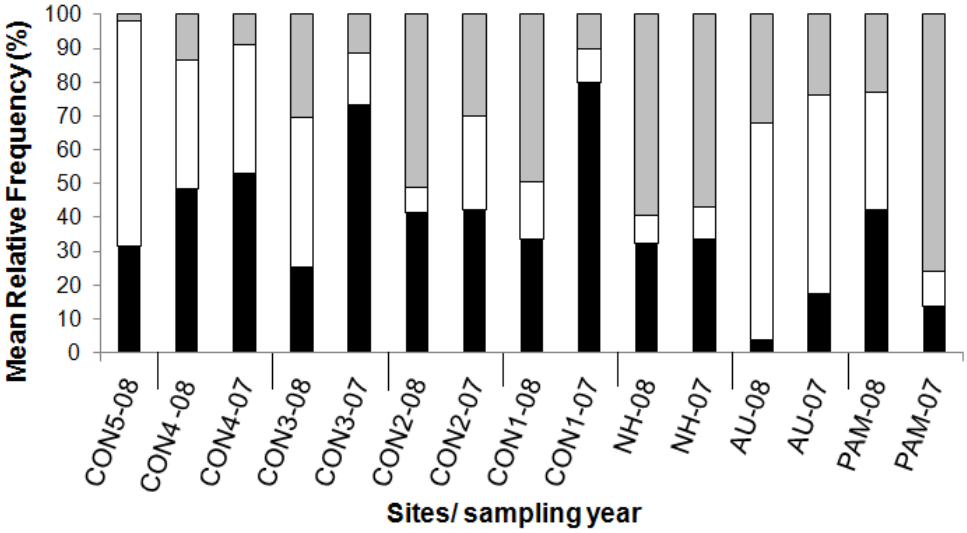


Mean home range size (km^2) of 7 female elk released in 1998, for 4 years after release.
*STUDENT POSTER

Anthropogenic Succession on Gold Tailings Amended with Organic Residual Materials from the Pulp and Paper Industry

Nicole Monette[1,2], Graeme A. Spiers[1,2], and Peter J. Beckett[2]
[1]MIRARCO [2]Department of Biology, Laurentian University

Establishment of a vegetative cover on mine wastes can be challenging because their properties are often not conducive to plant growth. Recently, interest is growing in recycling organic residual materials (ORM) (e.g. sewage sludge and pulp and paper sludge) from industry to use as a plant growth medium overlying inhospitable soils. Although this approach seems promising, some issues have arisen with the persistence of early seral communities, invasion by exotic species and subsequent inhibition of natural re-colonization. The objective of this study is to analyze changes in the pioneer community composition and to attribute some of the assemblage patterns to characteristics of the substrate. The study uses a chronosequence of 8 gold tailings sites that were amended with shallow covers (0.5m) of pulp and paper organic residues and then seeded. The plant community is assessed in terms of health, height, biomass and percent cover, using six quadrats, along each of two permanent transects at all sites. An overall site vegetation description is compiled using a presence/absence survey. In addition, the ORMs are characterized by parameters such as moisture content, bulk density, pH, redox-potential, metal content and nutrient availabilities. Preliminary data indicate that communities are healthy and productive. However, the plant communities are composed mostly of reclamation species and exotic species that are not typical of boreal forest succession. Depending on the final reclamation objective of the mining company, human intervention such as tree planting may be required to accelerate the progression towards a community that is typical of the surrounding ecosystem. The knowledge gained from this research will enrich our understanding of succession in general, especially ecological restoration in the Boreal forest. It will also contribute to the planning, monitoring and assessment stages of restoration projects using ORMs.



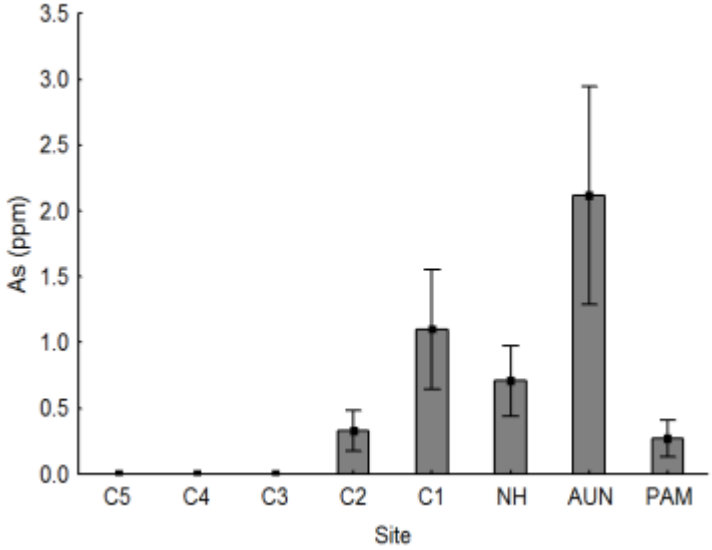
Relative frequency of legumes (black), grasses (white) and herbs (grey) for the 2007 and 2008 sampling years, grouped from the youngest site (C5) to the oldest site (PAM). Overall, the proportion of herbs increases with site age.

*STUDENT POSTER

Metals in Plant Tissues and Organic Residual Materials Overlying Gold Tailings in Timmins, Ontario

Nicole Monette[1,2], Graeme A. Spiers[1,2], and Peter J. Beckett[1,2]
[1]MIRARCO, [2]Department of Biology, Laurentian University,

Recently in land reclamation, there has been growing interest in recycling organic residual materials (ORMs) from industry and using them as a cover to help sequester potentially harmful or acid-producing, metalliferous mining wastes. ORMs can also make an excellent plant growth medium since they provide appropriate water holding and infiltration capacity, bulk density, nutrient availability and pH. This approach is appealing since it uses wastes that would otherwise be disposed of in landfills or incinerated. Although there are many benefits to recycling ORMs, there exist concerns over the possibility for upward mobility of metal(loid)s from mine wastes into the ORMs, potentially leading to water contamination or plant uptake. As part of an on-going study investigating successional trends on the tailings, this project examines the metal(loid) concentrations in above-ground plant tissues and pulp and paper organic residuals. The study uses a time chronosequence of 8 gold tailings sites that were amended with shallow covers of pulp and paper ORMs (0.5m) and then seeded. Biomass and ORM sampling was completed within the same sample plots, along each of two permanent transects at all sites. The total and bioavailable concentrations of metal(loid)s of concern such as Arsenic (As) are being analysed using plasma spectroscopy following digestion with concentrated acids. In addition, other substrate characteristics known to influence metal(loid) uptake such as pH, moisture content and redox-potential are being determined. Due to the benign nature of the gold tailings, we do not expect metal(loid) concentrations within plant tissues to be phytotoxic or pose any serious risks of food web contamination. Since this project is still in progress, only preliminary results for metal(loid) concentrations within plant tissues will be discussed.

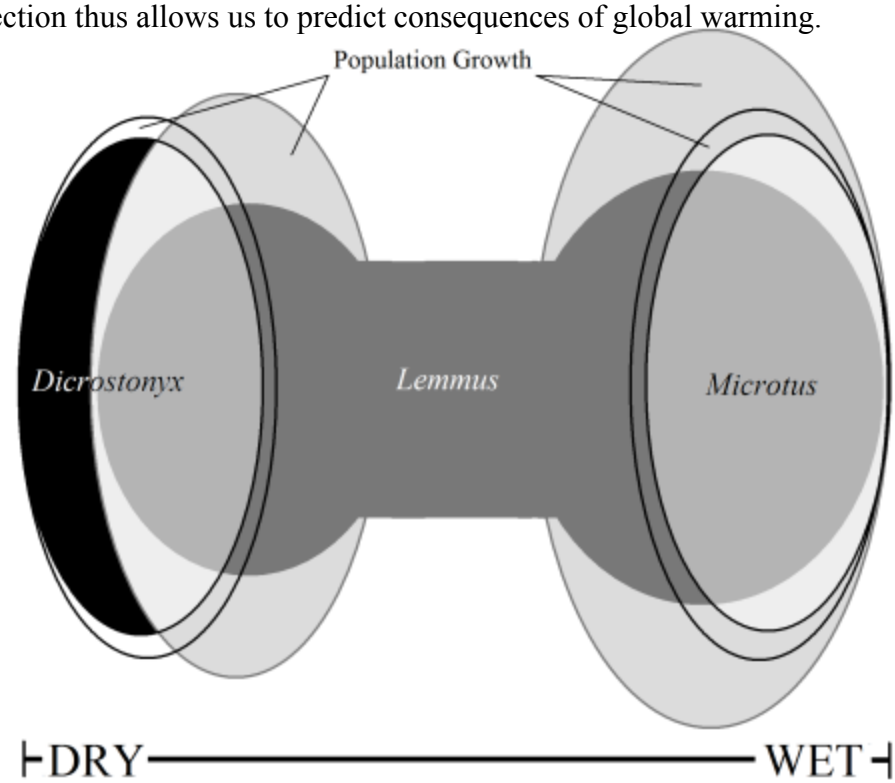


Mean (±SEM) of Arsenic (As) concentration (ppm) in above-ground plant tissues grouped by site, from the youngest C5 [left] to the oldest PAM (2008) [right].

Predicting Changes in Arctic Small Mammal Communities from Global Warming

Douglas W. Morris, Alissa Moenting, Angélique Dupuch, Som B. Ale, and Debra E. Moore
Department of Biology, Lakehead University

We attempt to understand the implications of global warming on arctic small mammal communities by studying habitat selection. Adaptive animals select habitat to maximise fitness, and that habitat selection is influenced by intra- and interspecific competitor densities. We ordinated habitat along a wet-dry tundra gradient and estimated the densities of three rodent species on Hershel Island, Yukon: *Dicrostonyx groenlandicus* (collared lemming), *Lemmus trimucronatus* (brown lemming), and *Microtus oeconomus* (tundra vole). We used Ivlev's electivity index to gauge the habitat preferences of each species. At the densities on Hershel Island, *Lemmus* is the only density-dependent habitat selector. Generalist *Lemmus* prefer wet habitat over dry tundra at all population sizes, but occupy both extremes of the gradient. Conversely, no matter their populations densities, *Dicrostonyx* and *Microtus* are specialists and each prefer only dry and only wet sites, respectively. Therefore, if global warming reduces dry tundra on Herschel Island, then *Microtus* should persist while *Lemmus* shifts its occupancy toward wet habitat. If global warming reduces wet tundra on Herschel Island, then *Dicrostonyx* should persist while *Lemmus* shifts its occupancy toward dry habitat. An understanding of habitat selection thus allows us to predict consequences of global warming.

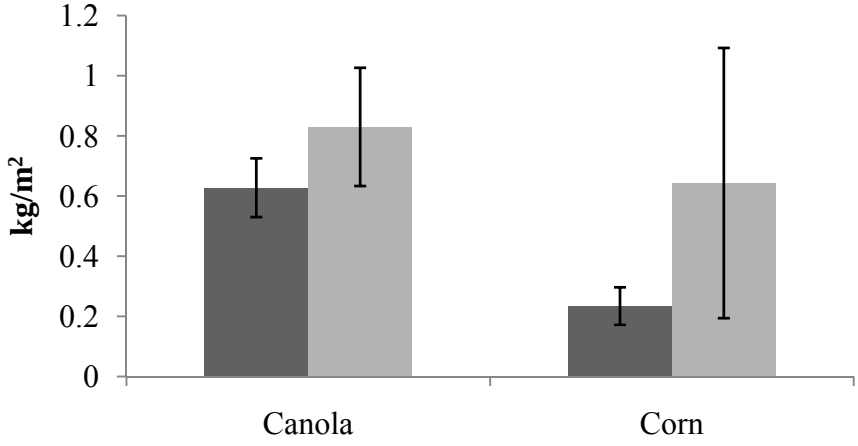


Schematic of three Arctic rodent species living in habitats along a moisture gradient: *Dicrostonyx groenlandicus* (dry specialist), *Lemmus trimucronatus* (generalist, and intraspecific-density-dependent habitat selector), and *Microtus oeconomus* (wet specialist).

The Growth of Biofuel Crops on Amended Mine Tailings

Tamara Posadowski[1,2], G.A. Spiers [1,2,3], P.J. Beckett[2], J. Hargreaves[1], and A. Lock[1]
[1]Centre for Environmental Monitoring, MIRARCO,[2]Department of Biology, Laurentian University, [3]Department of Chemistry, Laurentian University

As the need for greener energy solutions increases, the use of biofuels is becoming more common. However, the development of biofuel crops on prime agricultural land has caused much controversy, when this land could be used instead for food production. A possible solution to this issue may be found with use of the barren mine tailings that have been amended with organic residual material from the pulp and paper industry. This strategy was investigated on nickel/copper mine tailings in Copper Cliff, ON. Crops of short rotation dwarf corn and a northern variety of canola were grown, and data on plant growth morphometrics were collected. The growth at the tailings site was then compared to that of an agricultural site, located in Azilda, ON. Each site was divided into four plots, two planted with corn and two with canola, all of which were managed using traditional agricultural practices. Crops were monitored and sampled throughout the growing season, and crop measurements included biomass and plant heights. Dry biomass estimates indicated that the tailings site had significantly higher biomass yields (kg/m^2) for both corn ($P=0.0105$) and canola ($P=0.0097$), with no significant difference within sites. Plant height measurements produced similar results, with the tailings site having the greater plant heights for both corn ($P<0.01$) and canola ($P<0.01$). However, within sites, the tailings had significant differences in plant height for both corn ($P<0.01$) and canola ($P<0.01$), while the agricultural site did not ($P>0.05$). Even though the amended tailings site produced greater biomass and plant height results, the site data was much more variable when compared the agricultural site. Hence the use of amended mine tails looks promising for biofuel crop production, at least in the short term.

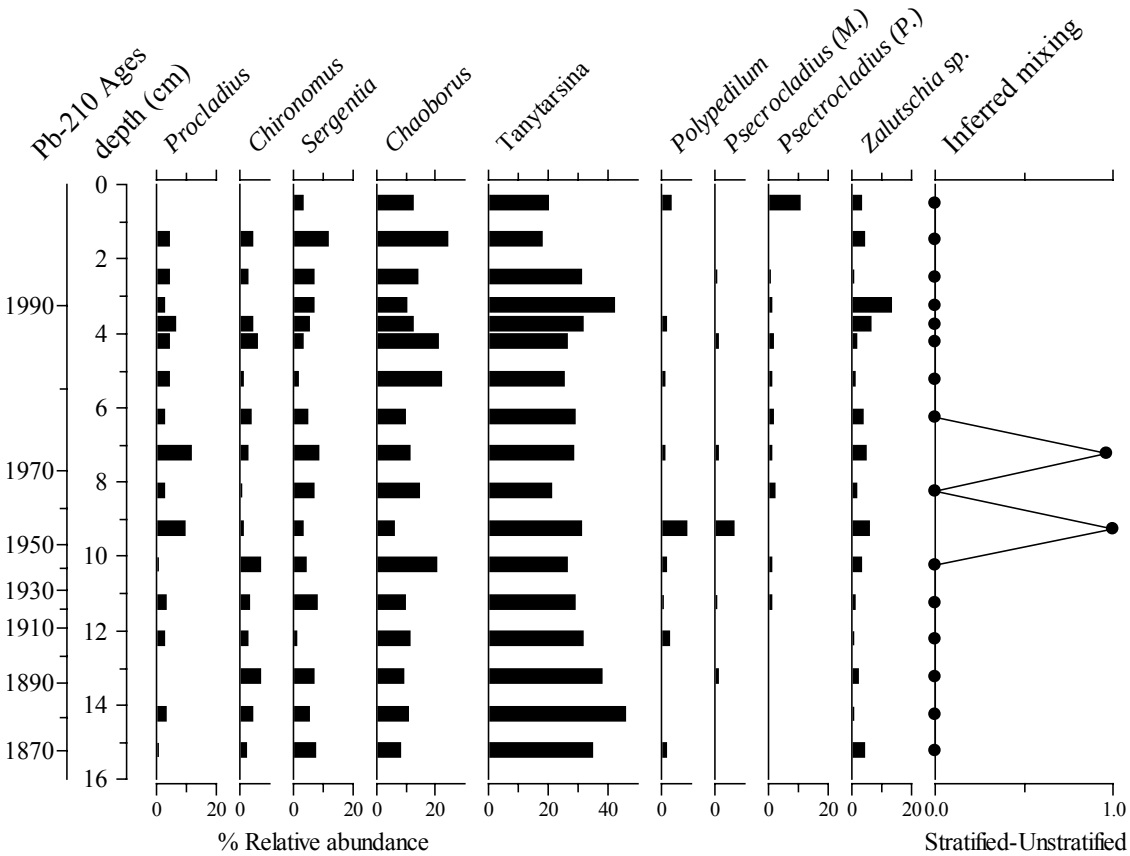


Dry biomass (kg/m^2) comparison between the agricultural site (dark grey) and the tailings site (light grey) (mean ± SD). The tailings site produced the greater biomass results for both crops when compared to the agricultural site.
*STUDENT POSTER

Inferring Thermal Regime in Shallow Boreal Lakes

Roberto Quinlan[1], Michael Paterson[2], David Schindler[2,3] and John Smol[4]
[1]Dept Biology, York University, [2]Experimental Lakes Area, Dept Fisheries and Oceans, [3]Dept Biological Sciences, University of Alberta, [4]P.E.A.R.L., Dept Biology, Queen's University

Predicted future changes to aquatic ecosystems include declines in maximum depth and shifts in thermal regime due to altered hydrological and biogeochemical processes in a warmer climate. These shifts may have particularly pronounced ecological consequences on shallow lakes. Multivariate ordination (Redundancy Analysis) of subfossil Dipteran assemblages in 35 boreal shield lakes in the Experimental Lakes Area (NW Ontario) indicated that maximum depth (Z_{max}) was the major environmental gradient structuring the composition of subfossil Dipteran communities in these lakes. A Z_{max} inference model ($r^2_{(jack)} = 0.68$) was developed, however, application of this model to a subfossil Dipteran stratigraphy from Lake 240 (L240) suggested that assemblages were not accurately tracking changes in Z_{max}. Further examination of assemblage composition using Principal Components Analysis (PCA) indicated that mixing regime (stratified or polymictic) had an overriding influence on Dipteran assemblages. A Dipteran-based inference model to reconstruct past changes in thermal regime may represent a new paleoenvironmental tool to track the effects of climate change on aquatic ecosystems.



Lake 240 stratigraphy and subfossil Diptera-inferred mixing regime.

Temporal and Spatial Predictors of Crayfish Declines in South-Central Ontario

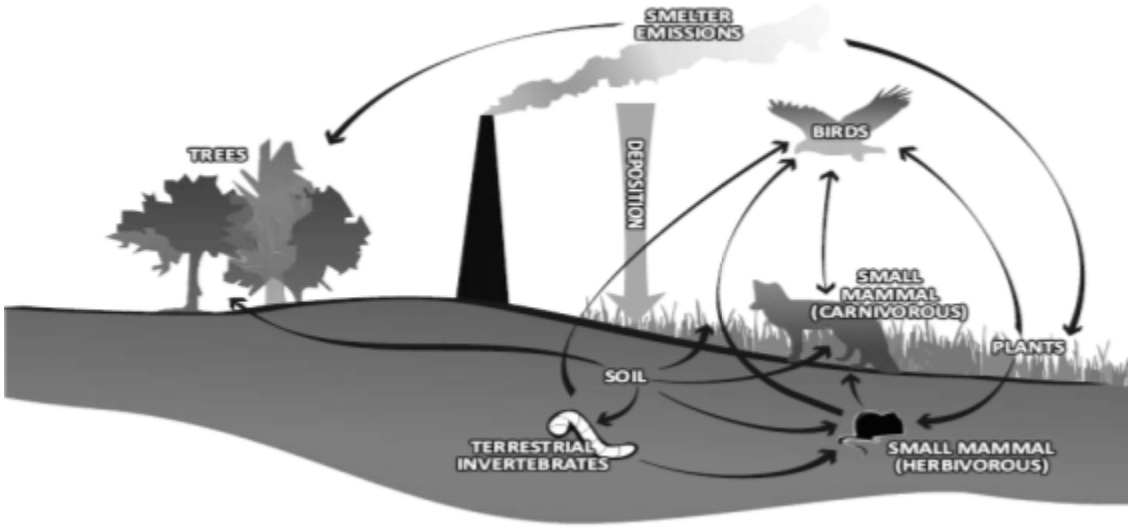
Rusak, J.A., B. Edwards, R.A. Reid, D.A. Jackson and K.M. Somers

Spatial surveys conducted across 100 lakes in south-central Ontario during 1994 and 2004 have shown that crayfish diversity, relative abundances, and distributions are declining on a broad geographic scale. Annual temporal surveys in a subset of these lakes have documented similar trends. We focus on this latter temporal dataset to examine the patterns and correlates of declining diversity and abundance using multiple regression and time series approaches. While the findings are consistent with declines in calcium concentrations in Shield lakes, there are multiple stressors, including climate change, altered habitat structure, oligotrophication, and introduced species that may also play a role in determining crayfish abundances. Teasing apart the relative influences of these and other stressors responsible for the decline in crayfish across this region remains an important goal for a better understanding of both the ecology and management of this important link in aquatic food webs.

Bioavailability of Copper and Nickel Contaminants Extracted from Soil in the Gastrointestinal Tract

Sarah Schoenau[1,2], Graeme Spiers[1,2] and Stacey Ritz[3]
[1]Laurentian University Dept. of Biology, [2]MIRARCO, [3]Northern Ontario School of Medicine

Metals are natural constituents of soils, and may also be contaminants from industrial processes. Soil ingestion by children occurs both by inhalation of large dust particles trapped by mucus and rerouted to the digestive system, and frequent hand-to-mouth behaviour. This study will examine the potential for absorption from the gastrointestinal tract of contaminant copper and nickel from an ingested soil matrix via a mouse model of exposure to soil pelleted into a mouse diet. The study will define both the upper limit of soil ingestion which does not induce taste aversion in mice, as well as the bioavailable portions of copper and nickel soil contaminants resulting from digestion. ICP-MS analyses of digested organs and tissues harvested from these mice will be compared to ICP-MS analyses of samples resulting from *in vitro* digestion of the test diets. Diet exposure to these soil samples may cause increases in the amount of bioaccessible and bioavailable copper and nickel, with increases being less than or equal to those observed in the *in vitro* digestion of the test diets. This study will provide the first *in vivo* examination of the impact of ingested copper and nickel-containing soils from a smelter region integrated with food on bioaccessible and bioavailable levels of metals. The study will shed light on the actual risks posed to children who accidentally or intentionally ingest soil, eliminating overestimation in risk assessment as an experimental variable. Moreover, these studies will provide results which validate the accuracy of *in vitro* digestion models by allowing for the quantification of bioaccessible values of copper and nickel from soil samples.



Exposure to contaminants deposited in soils from smelter emissions.

*STUDENT POSTER

Adaptation of Engineered Organic Tailings Cover as a Biofuel Crop Growth Medium

Samantha Smith[1,2], Graeme Spiers[1,2], Peter Beckett[1,2], J. Hargreaves[1], A. Lock[1]
[1]Centre for Environmental Monitoring, MIRARCO, [2]Department of Biology, Laurentian University

This project is a component of the Green Mines Green Energy initiative led by Natural Resources Canada. The objective is advance mine reclamation by demonstrating that mining lands can safely become agriculturally "productive" through the use of organic residuals. The study site is located at Xstrata Nickel in Onaping, Ontario. Municipal compost was applied as a cover to the neutral Cu-Ni tailings as a growth medium. Four energy crops were planted including a cool climate dwarf corn variety, a northern variety of canola, and two varieties of switchgrass. Crops were also cultivated at an agricultural reference site for comparison. Monitoring of the site included plant growth parameters, destructive plant sampling, and biosolids cores and profiles into the tailings. Plant growth parameters monitored were germination rate, plant height, number of leaves, and number of pods and cobs. Plants showed deficiency symptoms early in the season; fertilizer was applied, however stunted growth persisted. Thus, biomass yield was low in comparison to an agricultural reference site in the first year of the study. Future experiments will focus on determining the cause of the deficiencies to ensure a healthy crop for future sampling seasons. Also, second year monitoring of all parameters will occur to determine the sustainability of this reclamation practice.

Canola, Corn and Switch Grass growing on Engineered Organic Cover placed on tailings at Xstrata Nickel in Onaping, Ontario

*STUDENT POSTER

Evidence for Genetic Adaptation to Metals in Sudbury Area *Daphnia pulex* Populations by Gene Duplication

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The School of Public and Environmental Affairs, Indiana University
The Center for Genomics and Bioinformatics, Indiana University

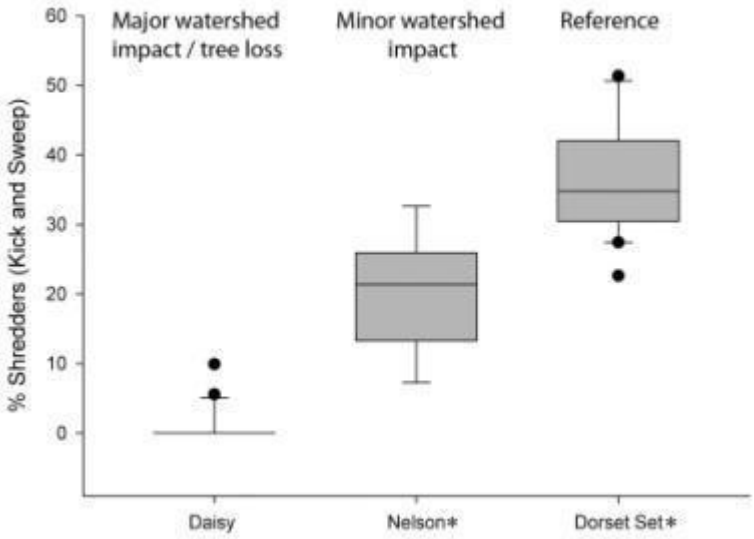
Due to the impact of industrial mining operations around the greater Sudbury area, native populations of the water flea *Daphnia pulex* have evolved to thrive in environments contaminated with cadmium, as measured by increased overall fitness in reproduction and growth. We show that the genetic adaptation of these populations is attributed to increased constitutive transcription of critical metals detoxification genes, most notably Metallothionein 1 (Mt1). Constitutive basal transcription (gene expression) of Mt1 is elevated to levels that are typically observed only as temporary, defensive, responses to metal stress. We discovered the molecular basis for this genetic change by comparing genome structure variation among adapted populations in Sudbury to cadmium sensitive reference populations. Significant variations in gene copy number are found within and among natural populations of *Daphnia* to propose that these important structural attributes of the genome are under natural selection. In the case of Mt1, we show that cadmium adapted *D. pulex* isolates in the Sudbury region all have greater gene copy numbers. Having discovered the DNA basis for this adaptation, we plan to use the full range of resources developed by the *Daphnia* Genomics Consortium to explore the history of gene copy number variation in *Daphnia pulex* populations of the Sudbury region through their resting egg banks found in lake sediments. *These studies contribute to and benefit from the Daphnia Genomics Consortium.*

*STUDENT POSTER

Healthy Lands Promote Healthy Waters: Terrigenous Organic Matter as a Subsidy for Recovering Consumer Communities in a Sudbury Lake

Erik J. Szkokan-Emilson
Cooperative Freshwater Ecology Unit, Laurentian University

Watersheds with healthy forests, productive wetlands, and organic soils provide clean water and a steady flow of organic materials and nutrients to receiving lakes. Many of the historically acid- and metal-stressed watersheds of the Sudbury area are devoid of these important organic matter and nutrient subsidies. Their lakes are characteristically clear and unproductive, and the nearshore benthic macroinvertebrate communities are less diverse than would be expected when compared to reference conditions. Recent work in the Daisy Lake watershed has uncovered positive relationships between forest and wetland cover, the export of particulate organic matter, and diversity of nearshore benthic macroinvertebrates. This work provides strong suggestion that terrestrial systems are providing subsidies to these recovering aquatic communities, and that without this important subsidy diversity is severely impaired. Dramatic differences in organic matter and nutrient quantities and proportions were noted in the discharge water from various streams within this watershed. Future work will address the causes of these dramatic differences, with investigation into nutrient cycles and fluxes in stressed catchments, and the potential of not only quantitative but also qualitative differences in exported materials. This research will help to understand how terrestrial systems subsidize aquatic food webs, as well as promoting land reclamation practices that will positively influence the biological recovery of lakes as well.



The proportion of leaf-shredder macroinvertebrates in two acidified lakes with different levels of watershed impact in contrast to a set of reference lakes.

*STUDENT POSTER

Geography of Waterbodies in the Airport Glaciofluvial System – Upper Junction Creek Valley Glaciolacustrine Sandy Deposits: Rare Earth Elements and Water Stable Isotopic Signatures – Preliminary Results –

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Large deposits of glaciofluvial sand and gravel are located north-east of the City of Sudbury, extending from the town of Garson to Lake Wanapitei. They form relatively higher grounds in the area and many creeks find their origin at their base (Emery Creek, Coniston Creek and Junction Creek). A number of kettle lakes are located on the core of the ice-contact stratified deposits. Because of the proximity of creek sources and lakes to the deposits, the question arises about the relationship between the hydrology in the vicinity of the deposit and the deposit itself, as gravel and sand have high infiltration and storage potential for rainwater. The purpose of this study is to look for geological provenance similarities in water quality of various waterbodies and for their dominant hydrological process in order to document their possible connection. Geological provenance is analysed by the composition of water in Rare Earth Elements (REE), during both high and low water levels. Additionally, the dominant hydrological process at time of sampling is detected using water stable isotopes analyses. Preliminary results indicate that there is much spatial and seasonal variation in REE signatures and dominant hydrological process. They hint at the complex geomorphic structure of the glaciofluvial-glaciolacustrine deposits, the role of human activities, such as mining operations and the influence of the hydrological seasons. In particular, more waterbodies share similar REE signatures during high water levels whereas more diverse REE signatures appear during low flow, suggesting connection during high water levels and isolation during low water levels.

Are Microbes Efficient at Economic Metal Extraction from Ores?

Aimee Williamson, Joinal Abedin, Christine Cousins, Troy Maki, and Graeme Spires
Laurentian University

Bio-mining is a cost effective, energy efficient and potentially environmentally responsible method of recovering a large variety of ore deposits by employing bacterial metabolic processes to enhance the solubilization of the metals(s) of interest. This method is useful for deposits ranging from high grade base metal deposits of nickel to lower grade uranium deposits, such as those found in the uraniferous quartz-pebble conglomerate beds of the Quirke Syncline, Elliot Lake, Ontario. The potential cost effectiveness of bio-mining in Elliot Lake strongly depends on the bacterially mediated dissolution of metals of economic importance. This presentation explores environmentally controlled, biologically mediated uranium ore extraction experiments. An overview of the elemental recovery results and release kinetics of more than 50 elements will be provided, with focus on rare earth elements, potential toxics and metals of economic importance. Furthermore, the importance of these findings will be put into an economic and geologic context for the re-development of the mining industry of the Elliot Lake Camp.

*STUDENT POSTER

The OWLLS Study - Water Level Fluctuation of Ontario Lakes: Character, Ecological Influence and Impacts of Regulation

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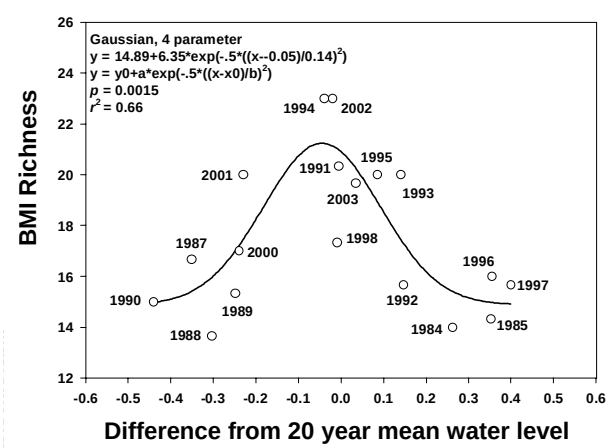
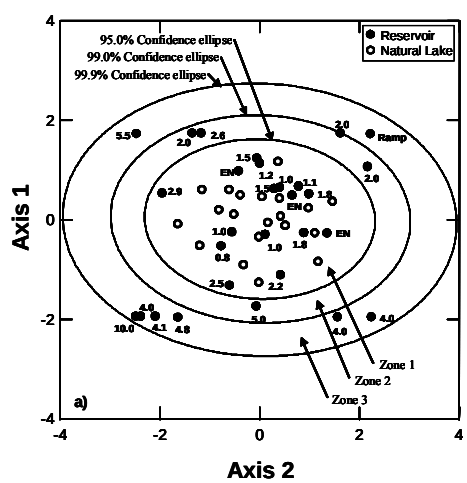
Recently, the topic of water level fluctuation (WLF) has received much attention in the popular media, especially due to declining Great Lakes water levels. Much less attention has been given to the ecological effects of WLF on the numerous lakes of Canada's Boreal Shield. Employing both, historical data collected from long-term research sites (~20yrs), and research from the OWLLS initiative (Ontario Water Level Lake Series), the effect of natural and regulated WLF on benthic macroinvertebrate (BMI) communities is addressed. Long-term WLF data reveal concordance with water quality parameters and demonstrate decreasing yearly amplitudes, mean water levels and a ten-year waveform oscillation of mean water levels. Further, BMI richness demonstrates a significant unimodal relationship (p = 0.002, r^2 = 0.66) with natural long-term mean water level. Analysis of 16 natural (no regulation) OWLLS study lakes show that BMI richness responds to natural levels of WLF. Using principal components analysis, we derived a new hydrologic variable D80-D210 (March 31st minus August 1st) as a surrogate for change in mean water level and found that BMI richness increases with decreasing D80-D210 values (r^2 = 0.38 $_{linear}$). Together these results suggest that a habitat squeeze in littoral areas is the direct result of lower mean water levels and that relatively small changes (~33cm) in natural WLF are associated with changes in BMI communities. Finally, a Reference Condition Approach (RCA) analysis of 20 natural lakes and 28 reservoirs (used for water power generation) demonstrates that reservoirs with yearly amplitudes > 2.0m have significantly different BMI community structure than natural lakes, and that BMI communities of reservoirs with yearly amplitudes > 3.0m have significantly different functional composition than that of natural lakes.



BMI richness highest in years close to mean. (Sparkling lake, LTER Wisconsin)



Reservoirs > 2.5m amplitude have different BMI communities than lakes.

Sincere thanks for the continued support of the Sudbury Restoration Workshop by our Sponsors.

And…

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