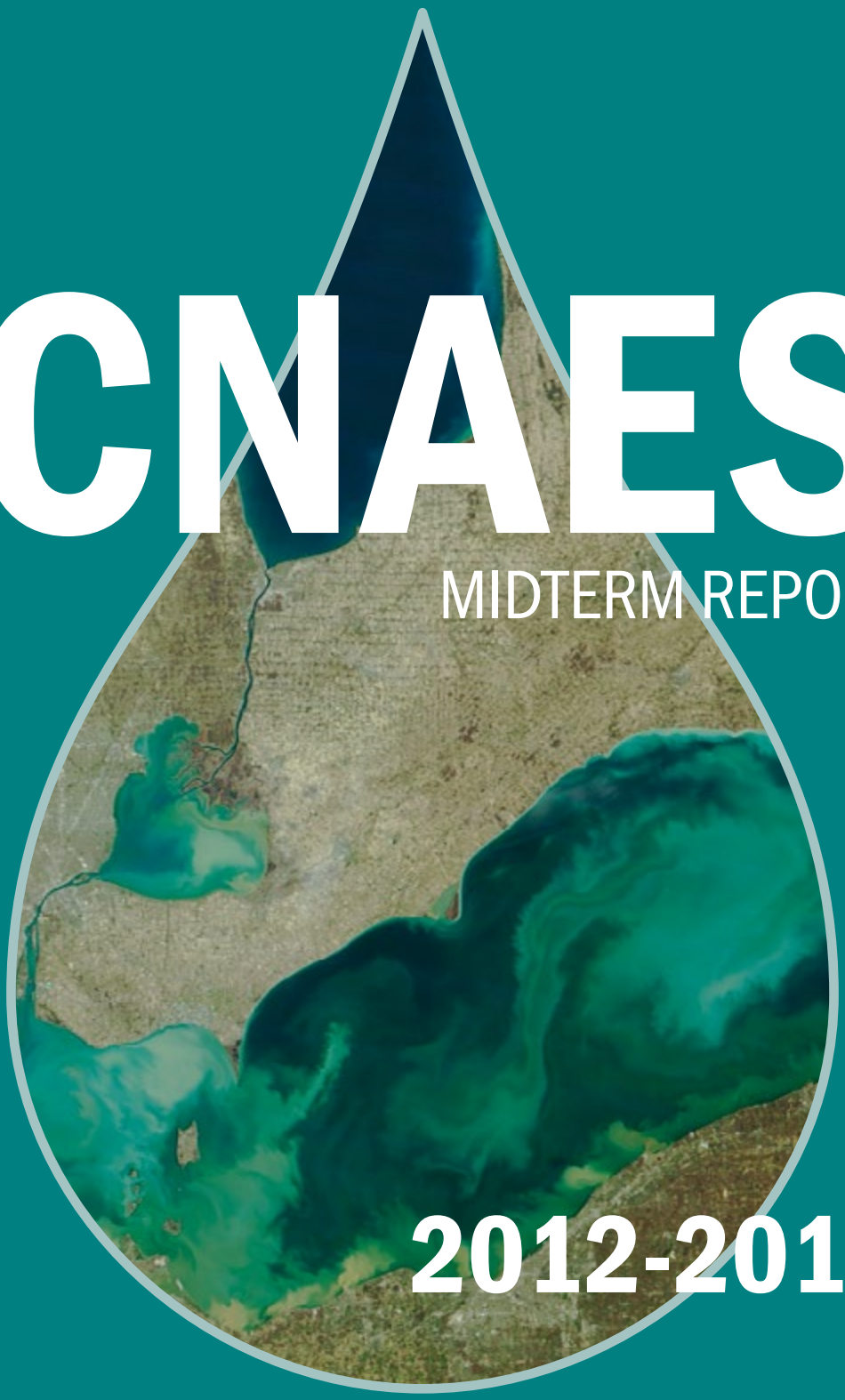
CNAES

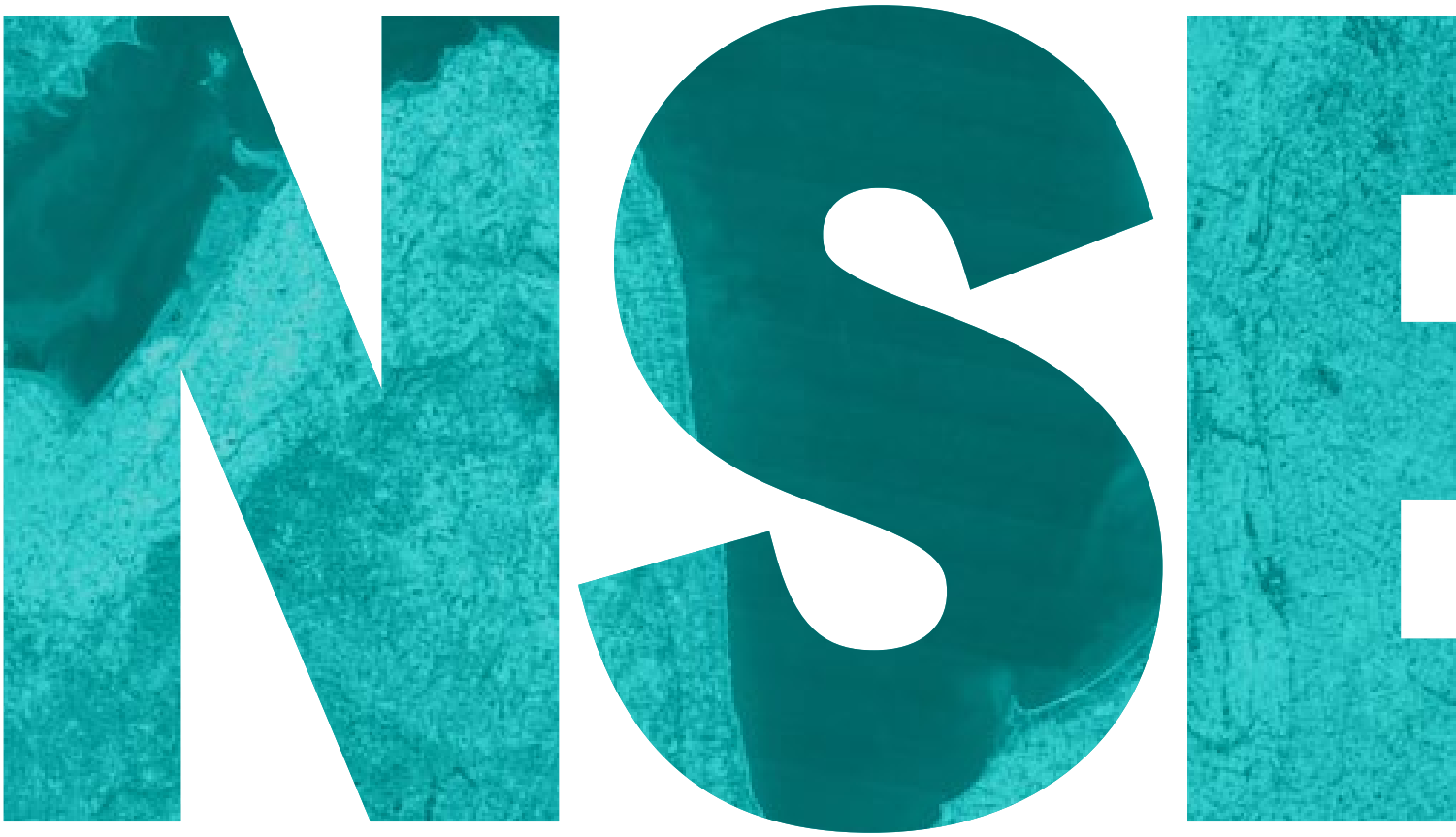
MIDTERM REPORT



2012-2015

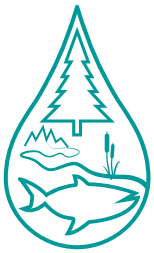
NSERC Canadian Network for Aquatic Ecosystem Services

Réseau Canadien sur les Services des Écosystèmes Aquatiques du CRSNG



CANADIAN NETWORK FOR AQ

UATIC ECOSYSTEM SERVICES



NSERC **R**éseau
Canadian **C**anadien sur les
Network for **S**ervices des
Aquatic **É**cosystèmes
Ecosystem **A**quatiques du
Services **CRSNG**

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Special Thanks:
Our deepest appreciation is extended to all CNAES members that contributed text and photographs on behalf of their project teams for this publication.

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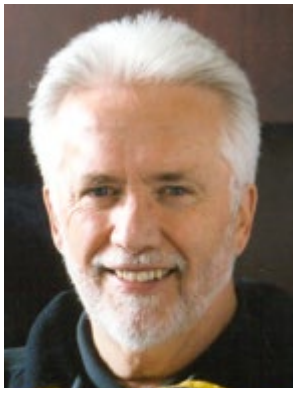
Board's Welcome

Welcome to the Midterm Report of the NSERC Canadian Network for Aquatic Ecosystems Services (CNAES). The Network is now halfway through its mandate, and the Board of Directors is pleased to report that CNAES is on track to complete the scientific projects within the three research themes. The Board continues to be impressed by the quality of the science being produced, and the commitment to integration within and between themes, as well as with other Canadian and international scientists. The Board is confident that CNAES will either meet or exceed its targets for the training of HQP personnel and commends the Network for its emphasis on communication of science to partners, aboriginal communities, and other users of the data and scientific knowledge.

CNAES is poised to make a substantive contribution to the informed development, use, and management of our natural resources through the generation of new knowledge, and the transfer of that knowledge by HQP to resource managers and policy decision-makers. This report provides you an overview of the progress of the Network in addressing its objectives, and we welcome your questions and requests for further details on the activities of CNAES. I want to thank the CNAES Principal Investigator, Dr. Don Jackson, for his leadership and continuing commitment to the Network, as well as the other members of the Scientific Management Committee, and the Co-Investigators for their dedication to creating this Network.

I also want to thank the students for their interest in making the Network work. Our partners have provided critical support to CNAES, and their engagement provides an ongoing stimulus to the research and training.

Finally, I thank the Board of Directors for its leadership and interest in the activities of the Network, and Jennifer Robinson for making the Board look good. The progress made by the Network during the first half of the mandate has raised the bar of our expectations for the next two to three years.



Jim MacLean
Chair,
Board of Directors

Director's Welcome

Water is critical to life and to our way of life. In Canada, we are blessed with an abundance of water that provided for Indigenous Peoples for millennia and served as routes for early French and English exploration and settlement. Water touches our lives in diverse ways ranging from providing clean drinking water; essential foods through fisheries and agriculture; hydroelectric power; routes for commerce; opportunities for recreation; and deep spiritual and cultural connections to nature. Water provides these numerous ecosystem services, but these services and the quantity and quality of water also depend on how we "value" what water provides, and ultimately the decisions we make regarding the preservation and development of our aquatic ecosystems.

I am pleased to welcome you to our NSERC Canadian Network for Aquatic Ecosystem Services (CNAES). Our mission is to develop the knowledge and quantitative tools necessary to understand the diverse range of Canadian aquatic ecosystems and their sensitivities and resilience to environmental disturbances. We are a highly collaborative partnership of researchers at many universities, government agencies, industrial partners and other agencies pursuing these goals. A significant component of our work involves the training of the next generation of academic researchers and leaders in government, industry and non-governmental organizations. I am proud of the excellent group of graduate students, undergraduate students and post-doctoral researchers that we have been training since the CNAES began in 2012, and the many successes they have achieved.

I want to express my sincere thanks to those actively supporting CNAES. Our various partners have provided excellent support through their financial, logistical and intellectual contributions. The range of the CNAES partners has grown since we began and this speaks to the broad importance of the underlying work and the significance of the issues. I am grateful to the insight and guidance provided by our Board of Directors, led by Dr. Jim MacLean, who have volunteered their time to help ensure the success of the CNAES. The Science Committee has provided excellent guidance and initiatives to our Network. Our Highly Qualified Personnel Committee comprising students and post-doctoral researchers, has been extremely valuable in advancing Network issues and aiding in the integration of various projects and researchers across the country. I thank Dana Moiana for her contributions that have ranged from assisting with the initial grant proposal application to the report you are reading. Finally, I would like to thank Jennifer Robinson, our CNAES Network Manager, for providing among many other things, the coordination and connectivity of our Network. Clearly, the operation and success of such a large and complex operation would not be possible without Jenn and her involvement in virtually all elements of the Network.

Don Jackson
Principal Investigator and
Scientific Director

OUR MISSION

The CNAES mission is to conduct research and training in aquatic ecosystem services across Canada. These services include, but are not limited to: nutrient cycling; water and food provision; flood regulation; recreational and spiritual benefits, amongst many others. With a focus on the northern wetlands, forest-aquatic connections, and lake ecosystems, the CNAES will develop quantitative tools and knowledge necessary to understand these systems and their sensitivities and resilience to environmental disturbances. The CNAES will determine the transferability of such tools and knowledge across the diverse series of landscapes and environments within Canada. Our work will provide government, industry, and other stakeholders with the information and approaches essential for making informed decisions regarding economic development while protecting the environment. The CNAES is training the next generation of leaders in this field for both the public and private sectors.

THE NETWORK

CNAES is a five-year Strategic Network funded by NSERC and multiple partners that began in 2012. It is a consortium of approximately 30 researchers from 11 universities, government, and industrial partners, plus over 50 graduate students and post-doctoral researchers, that conducts research on aquatic ecosystem services.

CNAES is led by senior researchers on the Science Committee and is governed by the Board of Directors, ensuring that all stakeholders are represented and that the Network is actively moving towards achieving its research goals and objectives.

theme

COUPLING THE LANDSCAPE, AQUATIC ECOSYSTEMS, SERVICES AND ENVIRONMENTAL CHANGE IN CANADA'S NORTH

Objectives

Canada's boreal and subarctic ecozones are not only its most geographically extensive and resource rich, but also very sensitive to climate change and development. The Hudson Bay Lowlands, located in Canada's subarctic region, is one of the five largest wetlands in the world. It encompasses arguably the most vulnerable of Canada's freshwater ecosystems, yet is virtually unstudied.

To help governments develop better management for this region, we intend to: synthesize existing knowledge concerning the aquatic ecosystem services; develop strategies for classifying and modelling water flows; understand the sources of water to streams and rivers; and develop a Reference Condition Approach assessment of aquatic species diversity and abundance to establish a baseline against which all future environmental changes and development may be gauged.

PROJECT I-1

A synthesis and analysis of existing hydrological, biological and chemical data for the Hudson Bay Lowlands

Objectives

The wetlands of the Hudson James Bay Lowland are a vital part of Ontario and are the largest source of freshwater to the saline James Bay, and represent a significant resource for First Nation's communities. However, little scientific information exists about how the Lowland functions. With the discovery of many mineral rich deposits, as well as a changing climate, it is critical to understand how the hydrology, ecology, and chemistry of this region are coupled, and how these changes will manifest across this ecosystem.

Our goal is to combine historical data from a range of private, public, academic and First Nations sources, to establish "snapshots" of the Lowlands at various points over the past half century from which changes may be detected.

Major implications for management and/or future policies

Ontario's Far North is undergoing considerable impact due to climate change and industrial development (e.g., Ring of Fire), and many of the impact assessments and guidelines being used are based on southern standards which are likely not applicable to northern systems. This project will provide insight into the changing hydrological regime of Far North, creating a baseline for management decisions.

PROJECT I-2

Couple the landscape and surface waters of the Hudson Bay Lowlands (HBL) at the regional, watershed and sub-watershed scales

Objectives

To evaluate the ability of watershed classification to characterize similar hydrologic landscape regions using hydrology, climate and physical landscape characteristics for the HBL, Canadian Shield and transition regions of the Attawapiskat watershed.

To evaluate relative contributions of groundwater to streamflow across stream orders from headwaters in the shield/lowland transition to the coast using water chemistry, water and carbon isotopes, and optical properties of dissolved organic matter.

Major implications for management and/or future policies

Testing of watershed classification approaches will improve understanding of the processes that deliver carbon (energy) and contaminants such as mercury to surface waters occurring within northern aquatic ecosystems

Determining the exposure of fish consumers to factors that can affect their health by systematically tracing the sources of water and solutes and coupling that to land use and climate change will be of particular importance to communities living within this region.

PROJECT I-3

Characterize the structure and function of aquatic ecosystems of the Hudson Bay Lowlands

Objectives

To conduct surveys of indicator species (zooplankton, benthic invertebrates) in Far North lakes and rivers in advance of industrial and climate change disturbances. Zooplankton were collected from 56 lakes to-date. Benthic invertebrates were sampled in more than 100 streams to develop Reference Condition Approach (RCA) models for comparison to models from other northern watersheds (Yukon, MacKenzie). We will also assess temporal variability at key assessment sites to better define future sampling protocols.

Major Findings

One of the surprising findings for the zooplankton survey was that the Far North lakes have much higher alkalinity than expected for Boreal Shield lakes. Lacustrine deposits and other glacial influences are presumably responsible for the high buffering capacity of these lakes, a factor that may provide added protection from atmospheric pollutants.

Major implications for management and/or future policies

These baseline surveys and assessment models will be key to the development of effective biomonitoring programs for the area in advance of climate change and industrial development.

PROJECT I-4

Identify the impacts of climate and land-use changes on peatland biogeochemical function in the Hudson Bay Lowlands scales

Objectives

The primary objectives of this study are:

- To form a comprehensive understanding of the transport and treatment of wastewater solutes in subarctic fen peatlands.
- To determine if wastewater contamination accelerates peat decomposition and determine the resultant change in hydrochemical properties.
- To identify a potential link between sulphate and methylmercury production.
- To recommend best management practices for wastewater polishing in subarctic fen weatlands.

Major Findings

Rapid sulphate and chloride transport was observed in low-lying preferential flow paths, while phosphate and nitrate were quickly removed from the pore water through biological or geochemical processes. High methylmercury concentrations were observed in conjunction with elevated sulphate levels.

Major implications for management and/or future policies

Limiting the water table rise in the treatment of fen peatlands due to wastewater polishing would increase treatment efficiency and limit the release of contaminants into aquatic ecosystems. This can be achieved by decreasing the volume of wastewater pumped into a single peatland and/or utilizing multiple peatlands. Sulphate may be a contaminant of concern in wastewater polishing peatlands due to its rapid transport and potential link to methylmercury production but requires further study.

PROJECT I-5

Characterize the distribution of mercury (Hg) and methylmercury in surface water and freshwater biota of the Hudson Bay Lowlands

Objectives	This project assesses spatial and temporal patterns in Hg bioaccumulation and biomagnification in fish species in lakes and rivers in the Far North of Ontario with a special emphasis on species harvested for food by First Nations communities. Along the coast of the Hudson and James Bays we are also studying factors that affect Hg in fish species (whitefish, sucker, pike, walleye) that may be affected, directly or indirectly, by migration to sea. We are assessing the fatty acids in migratory fish in order to contribute information on the nutritional value of country food.
Major Findings	Sample collection and processing are still underway with few results to date.
Major implications for management and/or future policies	These findings will have important implications for informing communities about more healthful fish (species, size, age, season, marine or fresh-water) for consumption.

PROJECT I-6

Building relationships with Far North Ontario First Nations

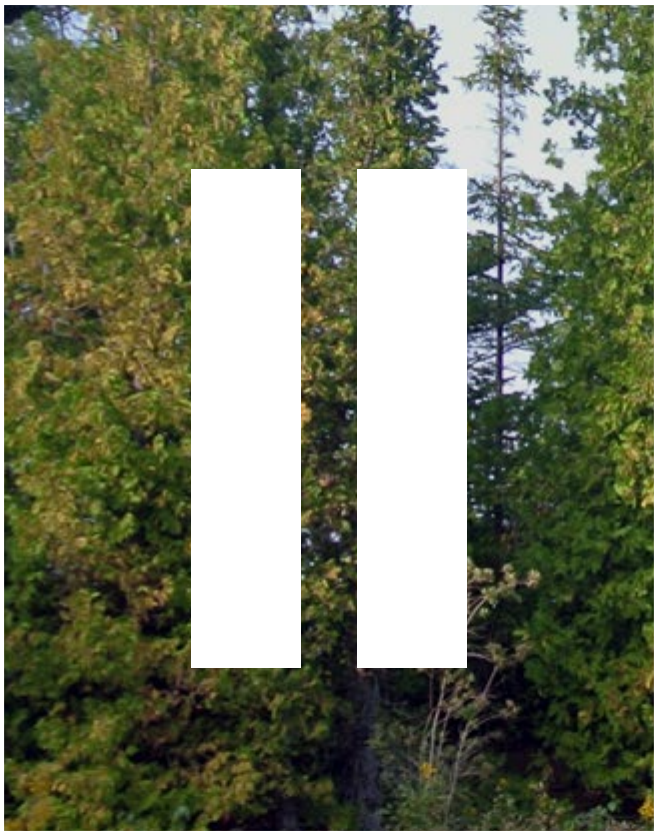
Objectives

Building trust-based, respectful and beneficial relationships with all First Nations is critical for the success of CNAES projects given we must conduct field work in their traditional land-use areas. Such relationships are required for the social license to carry out research in the region and therefore for a sustainable research program. Our approach is to i) engage young people in community schools with science activities broadly related to the science in Theme I and designed to motivate interest in environmental and earth sciences and ii) to speak with community members and leaders about benefits from the network's projects.

Major Findings

During the Spring semester and in two summer camps we interacted with 280 young people in five communities. By the end of 2015 the total was close to a thousand. We have taken aquaponics systems demonstrating the connection between terrestrial and aquatic ecosystems to two communities. We have developed and field tested graphic schemes for communicating fish consumption guidelines in collaboration with Project I-5 and the Ministry of Environment and Climate Change.

THEME



HEALTHY FORESTS, HEALTHY AQUATIC ECOSYSTEMS

Objectives

More than 50% of Canada's non-Arctic land base is forested, serving as source areas for important aquatic ecosystem services (AES). Governments need science to help them formally integrate AES into forest policy, planning and practices. On a pan-Canadian network of forested catchments, we are using monitoring, manipulative and modelling approaches to understand how forest management influences the delivery of and potential tradeoffs among AES at multiple spatial and temporal scales, to ensure that these services continue to provide benefits to society in a changing world.

PROJECT II-1

Physical, chemical and biological indicators of aquatic ecosystem services from headwaters of forested landscapes

Objectives

- Define regions of similar hydrological characteristics in forested landscapes using the Budyko curve and explain deviations from this curve using spatial characteristics.
- Establish a reference condition (RC) for AES that reflect spatiotemporal controls within each hydrological region.
- Develop distributed simulation models to explore the interactive impacts of spatiotemporal controls on AES.
- Apply the model to assess the potential for departures from the RC for AES caused by forest management practices.

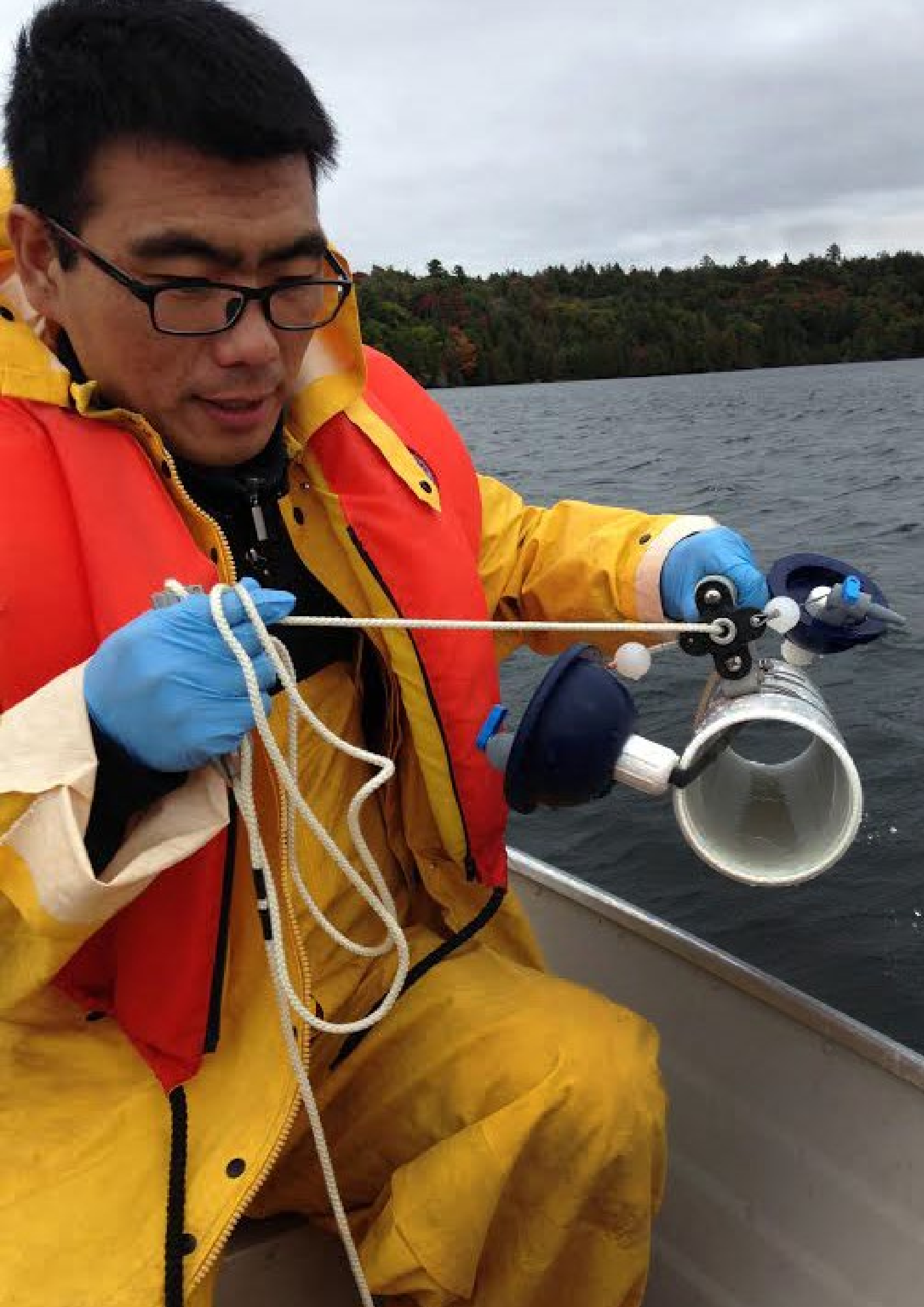
Major Findings

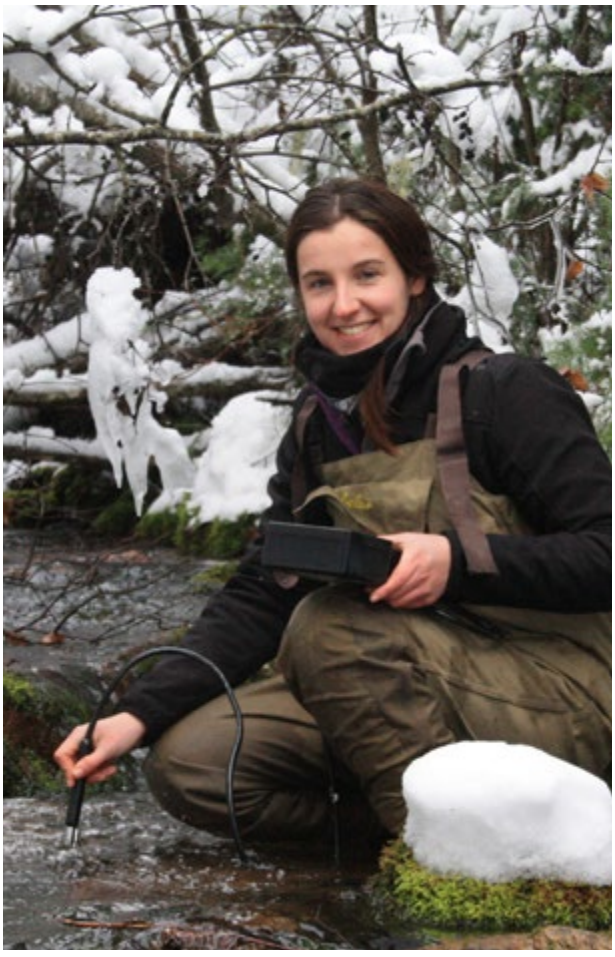
Streamflow regimes for unregulated drainage basins in Ontario can be explained using a hydrologic landscape classification based on hydroclimatic, terrain and aquifer indices. Distinct and discriminatory signatures in benthic invertebrate community composition in relation to forest condition and disturbance pattern indicates the possibility of developing models to predict the type of benthic community, and its associated AES, in a given forest region as affected by forest management practices.

Major implications for management and/or future policies

Development of a regionally-based hydrological classification system that can discriminate between natural vs. anthropogenic effects of forest management practices on hydrologically-linked AES.

Defining physical, chemical and biological indicators of AES will provide forest managers and policy makers with the critical information required for effectiveness and compliance monitoring of forest management decisions aimed at ensuring the sustainability of water resources.





PROJECT II-2

Experimental manipulations to test the effects of forest management activities on physical, chemical and biological indicators of aquatic ecosystem services from headwaters of forested landscapes

Objectives

Various indicators of forest management influences on streams have been proposed and observed. However, their generality as indicators and the mechanisms underlying those changes are poorly known, particularly in the context of AES. We seek to link indicators of AES to their causes and extend their potential applicability to Canada's forested regions and beyond. Among these indicators are organic matter amounts and decomposition rates in streams, and nitrogen dynamics.

Major Findings

Organic matter decomposition rates appear sensitive to forest management, recovering to pre-harvest levels after ~10 to 15 years, while benthic invertebrate communities do not. Organic matter export is a function of inputs and directly related to forest management at riparian and watershed scales.

Major implications for management and/or future policies

Biological measures such as organic matter processing and nutrient cycling, when combined with hydrological measures, show great potential for use as indicators of forest management impacts on AES. Decomposition rates, in particular, seem like a viable tool for wider application. Collectively, such functional measures can be used by forest managers to aid decision-making related to harvesting practices that explicitly considers potential impacts on, and conservation of, forest-based AES.

PROJECT II-3

Cumulative effects of catchment disturbances on downstream ecosystem services in forested landscapes

Objectives	Identify and evaluate a suite of physical, chemical and biological indicators to assess cumulative effects of forest management practices; Establish nested reference conditions for physical, chemical and biological indicators from undisturbed regional drainage basins; Establish the spatiotemporal character of disturbances within the landscapes; Establish the effect of these cumulative disturbances on physical and chemical indicators to biological indicators.
Major Findings	Rivers tend towards downstream chemostasis (active biogeochemistry, balanced organic matter quantity and quality); AES vary with floodplain position, emphasizing importance of upstream downstream connectivity; Engaging the community through participatory exercises leads to more complete maps of AES.
Major implications for management and/or future policies	Models considering the complexity of hydrological and biogeochemical dynamics will help predict the responses of riverine organic matter to environmental change; Enhanced spatial management strategies for AES should link upstream and downstream locations, integrating human and ecological factors to provide ecosystem services; Sources of conflict and cooperation among interest groups can be identified and ameliorated prior to escalation.

PROJECT II-4/II-5

Identifying desired social, economic, and aquatic ecosystem service futures and policy implementation needed to sustainably manage forest ecosystems

Objectives

Use scenario analysis and risk management assessments to establish sustainability of AES, to inform trade-offs from alternative forest management policies and practices, to establish potential future scenarios and explore policy options to move towards preferred scenario(s);

Assist governments and land managers in understanding ecosystem vulnerability under different policy options;

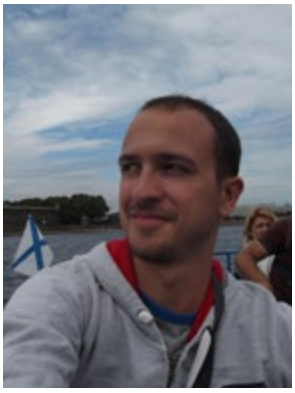
Develop frameworks for planning and implementation of policies to restore, reclaim and conserve forest resources.

Major Findings

Different techniques for aggregating indicators of AES result in distributions of AES outside the range of natural variation due to feedbacks; Models have been developed to explore the resilience of biological, chemical and physical indicators.

Major implications for management and/or future policies

The use of indicators to inform development and restoration objectives leads to systematic biases in the distribution of AES over time;
Different techniques for aggregating indicators of AES lead to different patterns of AES and highlight conflicts and synergies between different AES assessment methods;
Adaptive management for AES must consider feedbacks between behaviour under different policy rules and the effect of policy rules on changes in ecosystem function over time.



THEME

QUANTITATIVE INDICATORS & METRICS OF ECOSYSTEMS SERVICES, HEALTH & FUNCTION

Objectives

A key challenge for management and policy making is the assessment of ecosystem health and its relationship to the delivery of ecosystem services, as well as the risks involved in future but inevitable disturbances on services. We are developing quantitative tools to evaluate and link aquatic ecosystem services, ecosystem function, health and risk, as well as serve as monitoring tools for future evaluation. Out group of experts includes ecologists, hydrologists, statisticians, and natural resource managers developing a new generation of quantitative measures of ecosystem services imbedded into a landscape-scale perspective.

PROJECT III-1

Development of a pan-Canadian hydrological frame-work for modelling aquatic ecosystem services

Objectives

This project is creating consistent hydrographic data and information at high spatial resolution for all Canadian river basins to provide a standard database and geometric units within a Geographic Information System. The goal is to facilitate the integration between terrestrial and aquatic systems; and to support ecosystem service modeling by providing a hydrological routing framework that allows for assessing the effects of upstream changes on downstream aquatic systems.

Major Findings

To date, the project delivered a series of new data layers at a pan-Canadian scale, in particular a river reach classification, an estimate of long-term average discharge for every river reach, and a database of all lakes larger than 10 hectares, including estimates of their stored water volumes.

Major implications for management and/or future policies

The data and information framework are expected to support a multitude of applications with management or policy implications, ranging from the development of indicators of ecosystem risk and health to the assessment of environmental flow requirements at large scales. For example, the project already delivered indicators describing the cumulative effect of dams and reservoirs on ecosystem fragmentation and flow regulation to be used in risk or status assessments.

Preliminary result of the Canadian river reach classification representing one type of hydro-physio-climatic classes.

Understand the sensitivities and resilience to disturbance of Canadian aquatic ecosystems

PROJECT III-2

Fishing and safe consumption: understanding the drivers of provision and disruption of services

Objectives

Our overarching objective is to develop an aquatic ecosystem classification (AEC) model and inventory for lakes in Ontario. The AEC will help consolidate data, build predictive models, map key ecosystem structures and processes, and assess the potential impact of future changes in climate, effects of contaminants, and invasive species on two key aquatic ecosystem services: fishing and safe consumption at different watershed scales.

Major Findings

Systematic review of literature suggested that river-lake networks must be integrated in an AEC. We proposed a process that involves eight considerations, including: defining the goals of classification; database design; selection of spatial units; uncertainty estimates; and testing/validation.

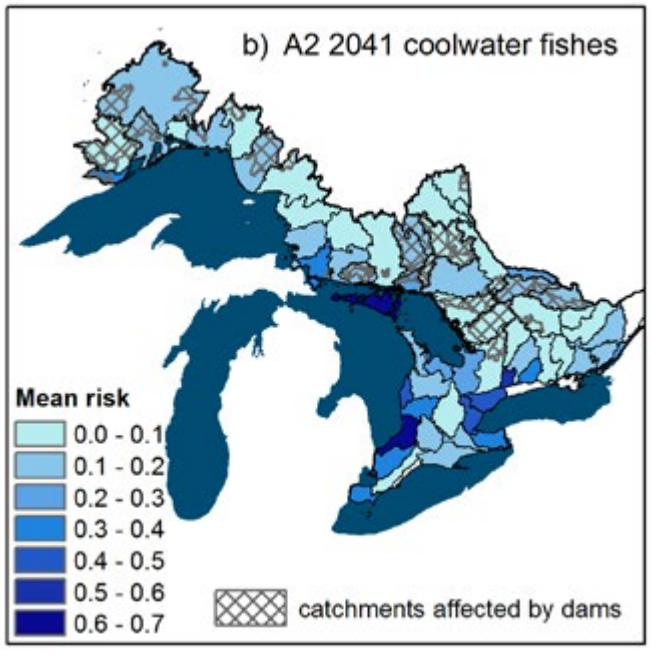
Mapped risk of invasion under projected climate change by cool and warm-water species found to be highest in southern Ontario and in northern watersheds draining into Lake Superior. Proposed dams could reduce access to potentially suitable habitat.

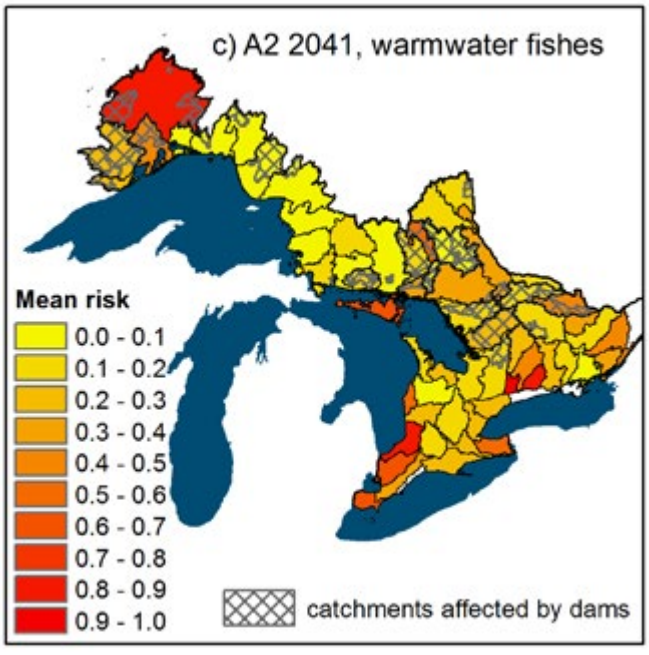
Major implications for management and/or future policies

Models of fish productivity in lakes can be improved by understanding how contributions from the land (local and upstream catchment) affect lake nutrient levels across different regions and watershed scales.

Analysis of fish mercury levels (for safe consumption) related to water chemistry, lake position, and catchment characteristics.

Evaluation of mean invasion risk provides a broad-scale comparative tool for management of invasive species control options (e.g., barriers) within and across tertiary watersheds.





Melles, S.J. et al (2015), Landscape Ecology 30: 919-935

PROJECT III-3

Calibrating the community size spectrum to serve as an indicator of the health of aquatic ecosystems

Objectives

- To estimate the parameters of the fish community size spectra of the lakes in central Canada, assess their sensitivity to differences in climate, nutrient status and fishing intensity and thus evaluate their utility as indicators of the capacity of lakes to support sustainable delivery of ecosystem services.
- To develop and field test new methods to reliably estimate the parameters of the community size spectra of lakes.

Major Findings

- Spectrum parameters of Ontario lakes respond to differences in climate, lake morphometry, water quality and angling pressure.
- Acoustic methods can be used to estimate the size spectra of lake pelagic fish communities with usable precision.
- Fish life history parameters change in concert with spectra parameters in ways that impact sustainable harvest rates.
- Telemetric and acoustic methods can be integrated to provide new and more effective methods of estimating the size spectra of fish communities.

Major implications for management and/or future policies

Differences in the size spectrum slope of fish communities are indicative of differences in the capacity of lake systems to support delivery of ecosystem services such as sustainable harvests of fish. Therefore the size spectrum slope promises to serve as a cost efficient, robust and logistically simple risk assessment tool for the delivery of ecosystem services.

Developing knowledge and quantitative tools

PROJECT III-4

Evaluating ecosystem health by quantifying resilience

Objectives

The primary objectives of this study are to:

- Develop a novel method for quantifying the resilience of ecosystems to disturbance.
- Evaluate the resilience of south-central Ontario freshwater zooplankton communities.
- Investigate the redundancy of physical and behavioral traits related to ecosystem function in freshwater fishes of Ontario as a surrogate for resilience.
- Develop a management approach integrating ecosystem services and resilience theory by incorporating ecological economic terminology.

Major Findings

Resilience is a complex topic incorporating many facets of ecology. A new approach to quantifying the resilience of communities to disturbance has been developed using long-term zooplankton species abundance data. More broadly, combining resilience concepts with ecosystem services frameworks provides an integrated approach for managing aquatic ecosystems.

Major implications for management and/or future policies

Understanding and preserving the ecological resilience and ecosystem services of Canadian aquatic ecosystems are two fundamental, interconnected strategies for ecosystem management. This project aims to bridge the gap between these two disciplines, and will provide a hybrid resilience/ecosystem services management scheme useful for aquatic ecosystem management.

PROJECT III-5

Geospatial risk mapping of aquatic systems across Canada:Determining regional generalities and local specificities

Objectives

This project models spatio-temporal fish data to improve decision-making for risk to ecosystem health and in turn human health in New Brunswick(NB). To achieve this goal, multivariate, geostatistics and network methods will be used to:

- Determine where fish community changes according to environmental conditions at the watershed-level.
- Model the cumulative effects of land-use on stream connectivity for salmon.
- Propose watershed management plans according the both regional and local conditions.

Major Findings

Trophic fish functional group response can be explained by environmental variation, primary productivity, and nitrite from fertilisers matching spatial areas with estuaries in NB. Fish functional groups based on habitat and migratatory traits show spatial variation in their responses within estuaries.

Major implications for management and/or future policies

Functional group responses can prove to be useful to identify the various effects of press and pulse disturbances within watersheds on land (logging, agriculture) and in stream (pollution), which are critical to manage aquatic ecosystem integrity and stream connectivity for fish. Fish community responses can therefore be used as indicators of spatio-temporal changes in environmental data which can help conservation and management of aquatic ecosystem services in estuary ecosystems in NB.

PROJECT III-6

Understanding the trade-offs among ecosystem services along disturbance gradients

Objectives

The objective for the first stage of this project is to examine the recovery of multiple aquatic ecosystem services (AES) following logging in western North America. The provision of roughly a dozen services were estimated across a 250 year chronosequence (based on relating forest structure to service provision) to identify the timeframe and shape of AES and to assess how AES recover in two distinct coastal forest types.

Major Findings

Each AES follows a unique trajectory with varying times to reach baseline levels ranging from 140 to over 212 years. These varying trajectories imply varying trade-offs and synergies over time following forest harvest. Riparian forests provide higher levels of most AES we examined than a forest on sloped terrain.

Major implications for management and/or future policies

Our empirical models of AES recovery help define the long-term dynamics of harvesting trade-offs and lead towards identifying management solutions. Options include conserving areas of old-growth forests that have high levels of AES of interest, working with First Nations to inventory AES such as large cedar, or lengthening harvest rotations. These results highlight the importance of tracking tradeoffs through time and provide practical guidance for sustaining multiple AES.

PROJECT III-7

The roles of habitat change and fragmentation in determining community composition

Objectives

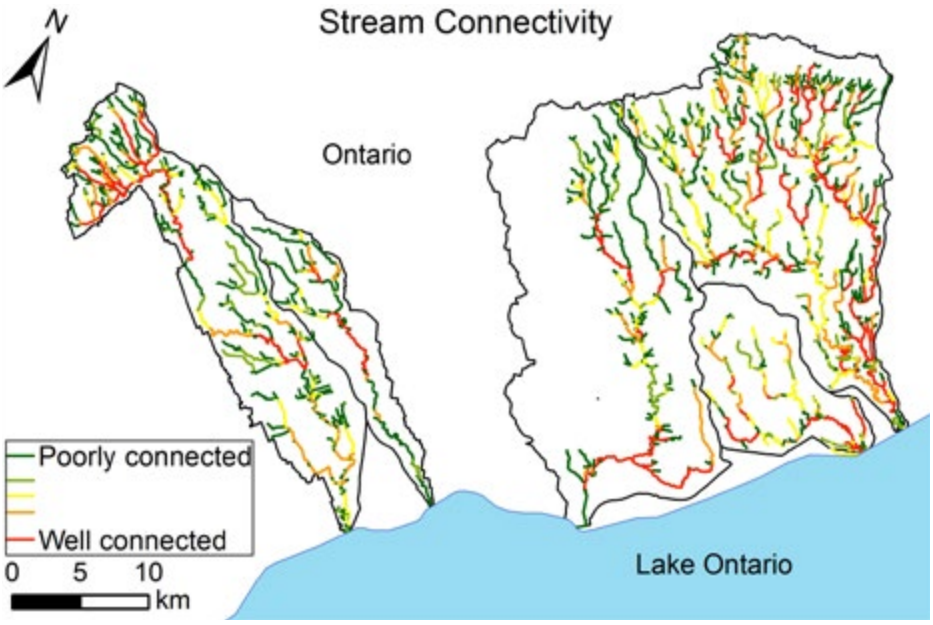
The major goal of this work is to understand the cumulative effects of habitat alteration and fragmentation on stream fish communities. Most aquatic ecosystems are undergoing environmental change which alters the spatio-temporal characteristics of their habitats. These effects are large in urban areas as land cover is currently being transformed from forest to agriculture to urban area. Urban development alters the conditions of habitats and road density is increasing, further increasing landscape fragmentation.

Major Findings

Land-cover change has a larger impact on local diversity likely because it alters the environmental characteristics of the habitat patch, altering which species can persist there. Fragmentation has a larger effect on diversity among sites, likely because it affects metapopulation/metacommunty dynamics.

Major implications for management and/or future policies

Work modelling aquatic connectivity in five watersheds in the Greater Toronto Region is being used by the Toronto and Region Conservation Authority (TRCA) to update their guideline for wildlife crossing structures in valley and stream corridors.



TRCA. 2015. Crossing Guideline for Valley and Stream Corridors. Toronto and Region Conservation Authority. 66 pages.

RESEARCH 'MEET & GREET' AT THE BATCHEWANA RIVER WATERSHED

Near Sault Ste Marie, Ontario

September 17-18, 2014

CNAES Theme II team gathered at the Batchewana First Nation Community Centre, hosting a "meet and greet" with a broad spectrum of interested community members who offered resounding support for a community-endorsed research program in the Batchawana River Watershed. This program will consider community concerns and incorporate community knowledge and data. We learned about the four sacred medicine rivers - Pukaskwa, Chippewa, Montreal and Batchewana - that course through the watershed. Community members shared their observations about changes in the structure and function of the watershed and had increasing concerns for the potential impacts of "extreme" events and the effects of pollution on the shoreline and near-shore ecosystem of Lake Superior. We are particularly excited about the possibility of research partnerships with the CNAES members, the local forest industry and the Batchewana First Nation, which has a strong understanding of the health of the watershed, indicators of changes in its health, and implications to their livelihood.

An outcome of our community meeting in Batchawana Bay on September 17th 2014 was that community members wanted an active role in the research being conducted in the Batchawana River Basin. One of our research projects involves conducting scenario analysis to envision alternative futures for aquatic ecosystems and make policy suggestions on how to arrive at the desired future. As part of the Sustainable Canada Dialogues initiative, we hosted a day-long workshop at the Batchewana First Nation Community Centre on November 21, 2014 with community members and project team members, guiding them through activities to envision and articulate their dreams for the future of the Batchawana River Watershed. This work contributed to a national snapshot of what people living in Canada desire for the future. Results of this activity will be included as a chapter in a white paper with responses to the Climate Action Plan that will include a chapter on the preliminary results of the visioning sessions.

INVOLVEMENT OF FIRST NATIONS IN THEME I FIELD WORK

First Nation community members have been employed to collect pike, whitefish and cisco at the mouths of the Moose, Albany, Attawapiskat, Winisk, and Severn rivers on James and Hudson Bay. Their field work has contributed to research on whether fish are moving from fresh river water to salt water in the bays; food quality in terms of valuable ingredients like omega 3 fatty acids; and mercury concentrations in fish of different species and sizes.

Lake and stream water chemistry sampling and collection of aquatic invertebrates and algae samples has been carried out in the Attawapiskat, Ekwan and Winisk River basins from 2013 to 2015. Led by Dr. John Bailey, this work has included regular meetings with Chief and Council for Marten Falls and Webequie to discuss sampling plans and present results, as well as training and hiring of First Nation field assistants. Data collected and sampling plans have also been shared with the Matawa and Mushkegowuk Tribal Councils. Members of Matawa First Nations on Lake Ramsey in Sudbury being trained in sampling and collection techniques by Dr. John Bailey and Jocelyne Heneberry (MOECC) from the Lake Centre. This training was part of programming offered by Matawa Four Rivers Environmental Services Group leading to certification of First Nation community members as environmental monitors. Bill Keller's work with fish and water sampling in the neighbourhood of Fort Severn and Peawanuck has also been done with First Nations guides and field assistants. Fish collection out of Fort Severn, as well as setting out remote monitoring instruments for the summer in the Severn River, has been carried out by those field assistants following Bill Keller's protocols. On the work have been prepared for the Fort Severn FN and the Weenusk FN. Progress on related fish and water projects near Fort Hope has also been summarized in a report for Eabametoong FN. The photo above shows graduate student Gretchen Lescord dissecting a fish on the shore of Ozhiski Lake with curious young First Nation onlookers.

BOARD OF DIRECTORS

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Elected Representative of the Co-Investigators and collaborators,
University of New Brunswick

**Served the committee from 2012-2014.*
*** Served from 2014 onwards.*

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2015

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A partnership involving academic,
government, industrial,
non-governmental organizations,
and indigenous peoples working together
to understand, protect and responsibly
use aquatic ecosystems

HIGHLY QUALIFIED PERSONNEL (HQP)

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Currier, Charisse - University of Toronto
Fung, Simon - University of Toronto
Fuss, Colleen - Western University
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Hanta, Gregory - University of Guelph
Hazra, Anika - University of Toronto
Miller, Johnston - Western University
Moiana, Dana - University of Toronto
Sarrazin-Delay,Chantal - Laurentian University
Spargo, Adam - Western University

HQP: THE FUTURE OF RESEARCH

CNAES is proud to be training the next generation of leaders in the field of aquatic ecosystem services (AES). With over 80 HQP in training to date, CNAES continues to expand and exceed its training goals. Many HQP are already taking their expertise beyond the Network to professional positions in the aquatic sciences:

Stephanie Melles

Current Position: Tenure-track faculty position at Ryerson University
Academics: Post Doctoral Fellow
CNAES Research: Classification modelling of aquatic ecosystems (e.g., high, medium, low productivity lakes) based on catchment charateristics across watershed scales. Interested in the question: how do lake ecosystem types relate to fish productivity and fish mercury levels.

Tara Despault

Current Position: Environmental Lab Analyst at De Beers Canada
Academics: MSc
CNAES Research: Optical measurements of dissolved organic matter in surface waters of the Attawapiskat River Watershed. Examining the potential for in situ proxies for mercury and characterizing water quality in northern peatland waters.

Lifei Wang

Current Position: Post Doctoral Research Associate at the Gulf of Maine Research Institute
Academics: Post Doctoral Fellow
CNAES Research: Using statistical approaches to investigate the relationships between the biomass size spectrum and environmental characteristics of lakes and fish mercury levels.

Josef MacLeod

Current Position: Fisheries Biologist with the Alberta Government Environment and Parks. Peace River, AB
Academics: MSc.
CNAES Research: Zooplankton and water chemistry survey of lakes in and around the "Ring of Fire" region in NW Ontario. Examining regional trends between Lakes of the Hudson Bay Lowlands and the Precambrian Shield.

Cindy Chu

Current Position: Research Scientist at the Ontario Ministry of Natural Resources and Forestry
Academics: Post Doctoral Fellow
CNAES Research: Examining the influence of regional and local environmental conditions and human activities on fish communities in Ontario's inland lakes. These analyses utilize data from MNRF's Broad-scale Monitoring program which sampled 720 lakes between 2008 and 2012.

Derrick de Kerckhove

Current Position: Research Scientist at the Ontario Ministry of Natural Resources and Forestry
Academics: Post Doctoral Fellow
CNAES Research: Use of fisheries acoustics for monitoring changes in size-spectrum in fish communities in lakes.

Pete Whitington

Current Position: Tenure-track faculty position at Brandon University
Academics: Post Doctoral Fellow
CNAES Research: Determine spatial and temportal trends in fish mercury concentrations with the antecedent hydrological and climatological conditions (e.g., dry vs. wet years) in Ontario's riverine systems.

Nicole Novodvorsky

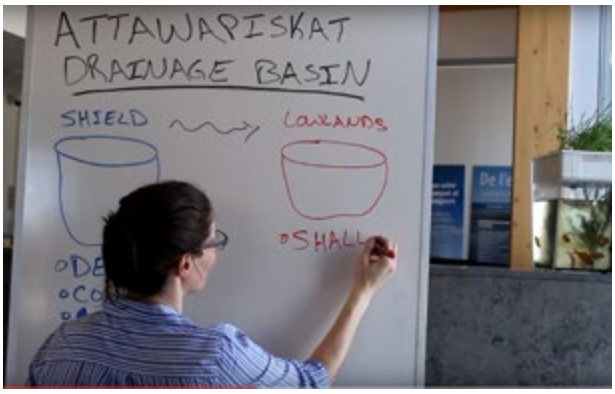
Current Position: Freshwater Ecology and Bioassessment Biologist at Laurentian University/ Ontario Ministry of the Environment and Climate Change
Academics: MSc
CNAES Research: Examined the effectiveness of predictive models for stream bioassessment using benthic invertebrate datasets from 3 distant watersheds in Canada.

1 MINUTE SCIENCE VIDEOS: SHARING SCIENTIFIC RESEARCH WITH THE GENERAL PUBLIC

In Spring 2015, the HQP Committee challenged the HQP to create 1-minute videos summarizing their research for a general audience. The following individuals accepted the challenge and created these fantastic communications pieces:

Geographic Extension of Benthic Invertebrate RCA Bioassessments: How Far Can We Go?

Nicole Novodvorsky, **Project I-3**



"Mercury cycling across a remote Boreal watershed in Northern Ontario"

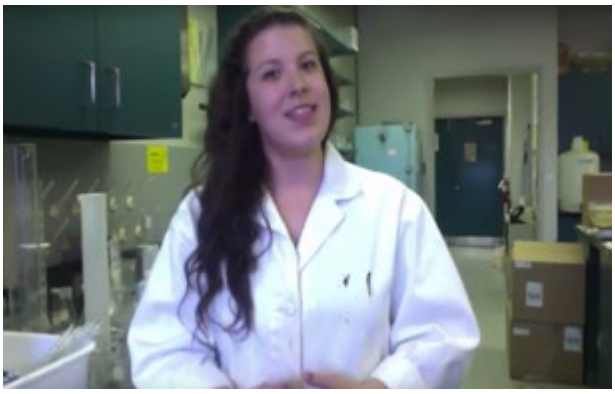
Gretchen Lescord, **Project I-5**

Effect of forest condition on food web structure and other aquatic indicators in headwater streams in different regions of Canada

Maitane Erdozain, **Project II-2**

Impacts of forest harvesting on stream nutrient processing mediated by organic carbon-nitrate

Alex Yeung, University of British Columbia, **Project II-2**



Assessing the Impacts of Forest Disturbance on Aquatic Ecosystem Services

Kristin Daoust, **Project II-1**

Feedbacks and Dynamics of Aquatic Ecosystem Services in a Multi-use Watershed

Stephanie Tomscha, **Project II-3**

Evaluating ecosystem health by quantifying resilience

Karl Lamothe, **Project III-4**

Understanding the trade-offs among ecosystem services along disturbance gradients,

Ira Sutherland, **Project III-6** *(Winner of the 2015 NSERC Science, Action! Competition)*

ANNUAL MEETINGS

Each year, CNAES researchers gather to discuss research progress and to enhance collaboration across the network. Each meeting includes keynote speakers, a poster session, training workshops, Theme meetings, and meetings of the Board of Directors, Science Committee and the HQP Committee. It is an excellent opportunity for networking and information sharing, and it is well-attended every year.

1st Annual Meeting

Vale Living with Lakes Centre,
Sudbury, Ontario
April 29 - 30, 2013

Our first full meeting of the CNAES focused on networking, preliminary research progress and future planning .
Highlights: keynote presentations from senior research scientists, and a workshop on best practices in working in the traditional territory of the First Nations communities.

2nd Annual Meeting

UQAM,
Montréal, Quebec
April 30 – May 2, 2014

We expanded the training to a full-day workshop for HQP. Topics included GIS training and plain language communication.
Highlight: the 3-minute 'Lightning Talk' presentations from all HQP.

3rd Annual Meeting

Sault College,
Sault Ste Marie, Ontario
April 28 – 30, 2015

We had a full-day workshop for all CNAES members, including discussion of ecosystem services frameworks and inter-Theme topics .
Highlights: 1-minute science video competition, led by the HQP Committee, and the 3-minute 'Lightning Talks' presented by all HQP.

OUTREACH INITIATIVES

CNAES is committed to communicating its research findings to relevant stakeholders.
CNAES researchers have already made dozens of presentations at national and international conferences and meetings.
The following are highlights from the 2014-2015 year:

Science for a Changing North IV: "Northern Watersheds and Ring of Fire Area Studies"

Vale Living with Lakes Centre, Laurentian University, Sudbury Ontario

February 18, 2015

CNAES Theme I researchers gathered to present their research in Ontario's Far North. Representatives from the mining industry, government and non-government agencies and academic institutions, engaged in discussion of the environmental and social impacts of development and climate change on aquatic ecosystem services in this region.

Size-Based Models of Aquatic Ecosystems: Theory and Practice.

American Fisheries Society (AFS) Annual Meeting Quebec City, Quebec

August 18-19, 2014

Hosted by CNAES Theme III researchers and attended by international scientists actively working in this field, this symposium focused on how size-based ecosystem models can be used to understand and manage marine and freshwater aquatic ecosystem services. Participants discussed the utility of these models in describing, managing and such as exploitation, eutrophication, and climate change. Presentations covered new research results from North American, South American, European and African systems, thereby promoting international collaboration on this promising approach to aquatic ecosystem management.

Aquatic Ecosystem Services Symposium
Joint Aquatic Sciences Meeting (JASM)

Portland, Oregon

May, 2014

CNAES researchers from all three Themes hosted a one-day symposium showcasing the broad context of aquatic ecosystem services through fundamental and applied studies drawn from diverse types of aquatic systems (lake, river, wetland, marine). Although the emphasis was on the underlying science, the symposium also examined broader societal issues including cultural, economic, and policy implications of aquatic ecosystem services.

PARTNERS AND COLLABORATORS

CNAES research would not be possible without the tremendous engagement and support of our formal Partners & Collaborators:

Alberta Innovates

Ontario
MINISTRY OF THE ENVIRONMENT

De Beers
CANADA

Ontario
Ministry of Natural Resources and Forestry

Detour Gold

Ressources naturelles et Faune
Québec

Fisheries and Oceans Canada / Pêches et Océans Canada
Oceans and Habitat / Océans et Habitat

UBC
THE UNIVERSITY OF BRITISH COLUMBIA

LaurentianUniversity
UniversitéLaurentienne

UNIVERSITY OF TORONTO

Natural Resources Canada / Ressources naturelles Canada

Western

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CONTRIBUTING PARTNERS

We also extend our sincerest thanks to the following organizations for their support and contributions to CNAES projects:

CANADIAN WATER NETEWORK
RÉSEAU CANADIEN DE L'EAU

Parks Canada Parcs Canada

CLERGUE FORESTMANAGMENT INC.

Garfield Weston FOUNDATION

Helmholtz-Zentrum Geesthacht
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