

The Government of Northwest Territories and Wilfrid Laurier University Partnership:

Ten years of sharing knowledge and building capacity together



A Partnership between researchers and communities that creates robust scientific knowledge with impactful outcomes.



Founding a Strong Partnership



In May 2010, Wilfrid Laurier University and the Government of the Northwest Territories signed a 10-year partnership agreement to expand the Territories' capacity to conduct environmental research and monitoring and build the expertise needed to manage its natural resources for future generations. Being involved in the initial partnership development remains one of the highlights of my administrative and research career.

Looking back, Laurier's initial research goals were to investigate landscape and hydrologic changes, forest fire dynamics and sustainable communities. I am pleased to see that not only have we generated a significant amount of data in these areas, our researchers and their students have also built meaningful relationships in the communities where they work.

These relationships help us better understand how we can meet community needs and deliver the training needed to empower citizens in the North as they navigate the impacts of climate change and resource development. Our researchers have spent almost a decade working to support communities, educate youth and re-establish connections to the land. Empowering communities is the essence of knowledge mobilization and a key component of Laurier's research mission.

This partnership between Laurier and the Government of the Northwest Territories has improved our understanding of the environment and related socio-economic factors in the North. We hope the knowledge we have built together will help inform regulatory policies and decision-making in communities.

I look forward to seeing how this Partnership will continue to evolve and grow to achieve our shared goal of "science in the Northwest Territories, for the Northwest Territories, and by the Northwest Territories."

A handwritten signature in dark ink that reads "Deborah MacLatchy".

Deborah MacLatchy, PhD
President and Vice-Chancellor
Wilfrid Laurier University

A Fruitful Partnership



Our Partnership with the Government of the Northwest Territories has been a central focus of Laurier's northern research initiatives, and the success of the Partnership has exceeded our expectations when we embarked on this journey in 2009. The expansion in funding, in projects, in interaction with communities and in the broadening of the research agenda has been a testimony to the vision that was embedded in the development of the Partnership.

Our relationship with the Government of the Northwest Territories and communities is based on our commitment to 'impact', working with our partners on the ground at research sites including Trail Valley Creek, Scotty Creek, and in communities and locations across the NWT. Our activity in the North is based on the growth of supporters and funders that have invested in the vision of our Partnership to build operating capacity and infrastructure across the NWT. In 2017 I was pleased to welcome guests, researchers, and community members to the opening of our Yellowknife Research Office. It is exciting to have a place where our researchers can work and join the day-to-day fabric of the Yellowknife community.

Of particular significance are the experiences and training that students of all levels have had through participating in northern focused research, through increasing their involvement with communities and expanding opportunities for community-driven research. Laurier students have come away transformed by their learning and experiences on the land and through their field work in the NWT. These young people who have been inspired by the north are a testament to the long-lasting impact of the Partnership in blending on the land knowledge, capacity building and scientific training.

This report illustrates a sample of the work of the over 270 students, over 15 universities who are involved in Laurier-led research in the NWT. The number of students working in the North has expanded 10-fold during the maturation of the relationship, and we look forward to continue to broaden the relationships and to continue to create together projects that use science and local knowledge to inform policy and decision-making in the North by communities and decision makers at all levels. We look forward to continue to enhance and expand the research in other disciplines important to the development of NWT communities, including agriculture, waste management, community development, food security, and public health and catalyzing opportunities for emerging knowledge-based businesses.

Laurier is committed to continue to nurture our working relationships across the north and the NWT. I look forward to another ten years of fruitful collaboration as part of our Partnership.

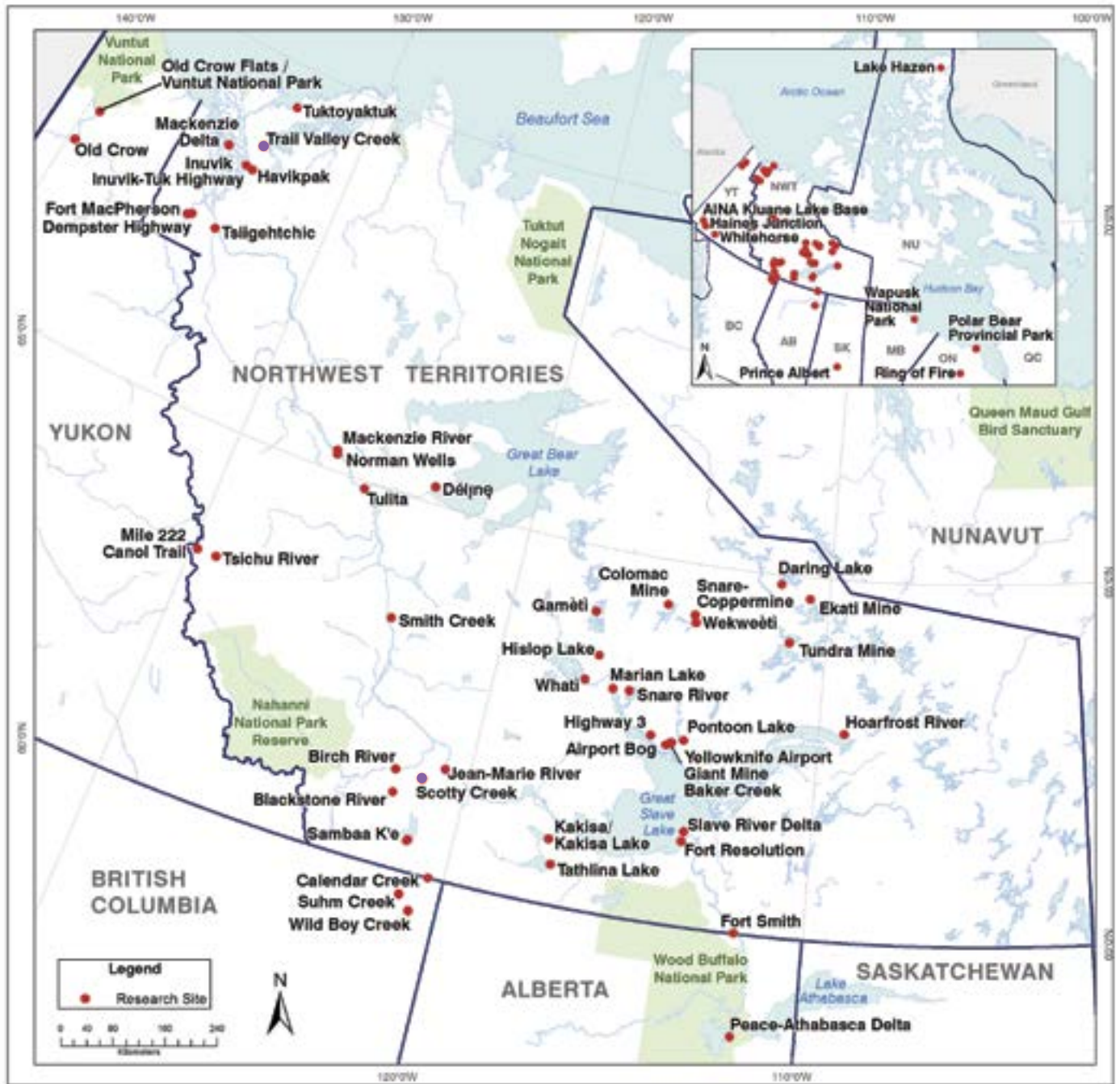
A handwritten signature in black ink, reading "Rob Gordon". The signature is fluid and cursive.

Robert Gordon, PhD

Provost and Vice-President: Academic, Wilfrid Laurier University

Map of GNWT-Laurier Projects Across the NWT

Projects and student work taking place across the NWT and beyond are indicated on the map below and in detail throughout the following sections.



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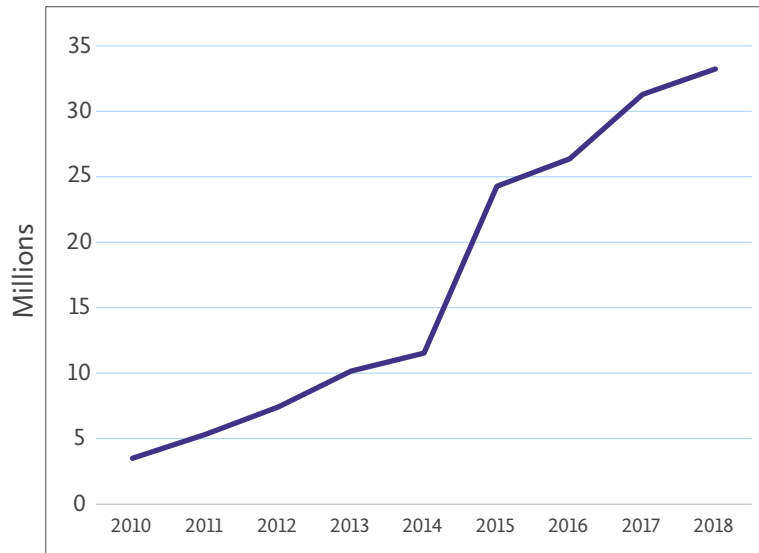
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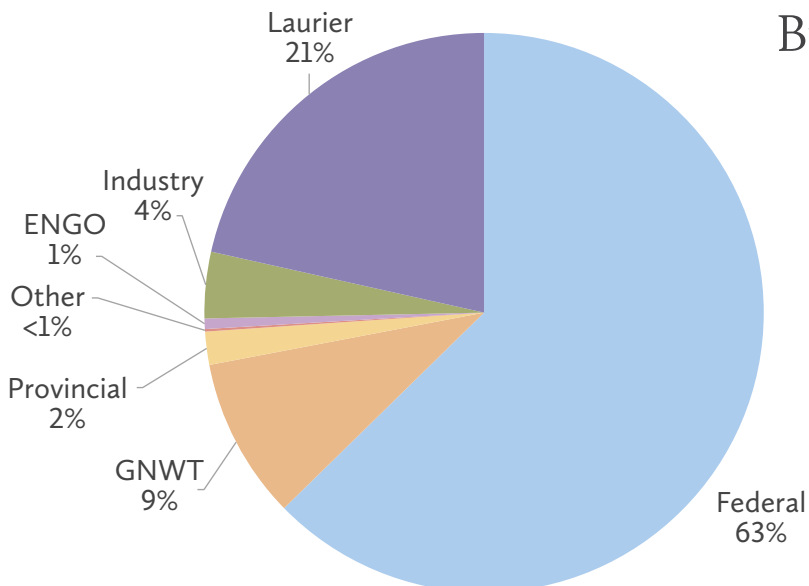
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Research Funding Awarded 2010–2018

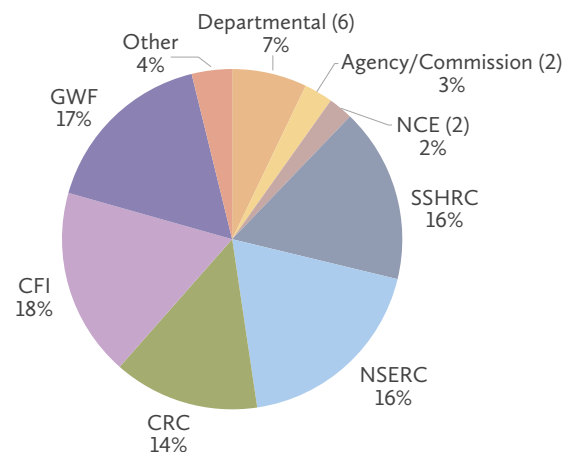


Financial support for infrastructure and personnel training in the Northwest Territories (NWT) has grown exponentially, and is approaching \$34M since 2010, resulting in a tenfold return on investment by the Government of Northwest Territories (GNWT). The diversity of funders of projects has expanded to include six federal government departments, environmental non-governmental organizations, and all major research funders in Canada across both social sciences and natural sciences disciplines.

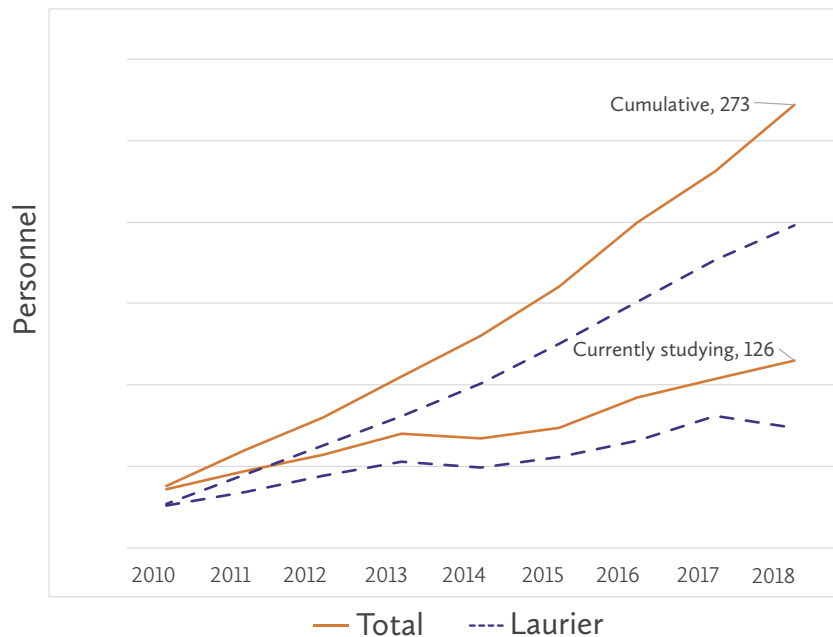
Total Funding Sources



Breakdown of Federal Funding



Personnel Trained in the North



The GNWT-Laurier Partnership has significantly grown the numbers of students trained to work in the North and contributed to the growth of scientific monitoring and knowledge. Over the past 10 years, more than 273 undergraduates, graduate students and postdoctoral researchers have contributed to extensive research projects across the NWT. Additionally, research teams have expanded to include trainees from 15 universities including Laurier, fostering collaborations and knowledge sharing.

Key Accomplishments of the Partnership:

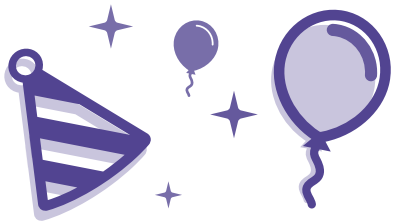
- Creating new knowledge, predictive tools, and community-based training that support the development of governmental guidelines and policy;
- Establishing the first boreal forest dynamics plot in the NWT as part of the Smithsonian Institute Forest Global Earth Observatories (ForestGEO) Network;
- Developing two world-class “living laboratories” with scientific equipment in the Arctic (near Inuvik and Fort Simpson).
- The laboratories are focused on understanding land cover change and its implications for ecosystem function at key transition zones where warming is driving exceptionally rapid change;
- Partnerships with local communities, the GNWT and industry to develop baseline ecological data and determine the impact of coupled environmental change and industrial activity in the NWT;
- Opening Laurier’s Yellowknife research office, to better meet the research needs of the GNWT and NWT communities.

Ten Years of Research and Training Success

\$33.5M
in research funding

including

16 Diverse Funders
6 Federal Departments
2 Federal Commissions



2017

Yellowknife
research office
grand opening

273

Laurier trained
personnel across

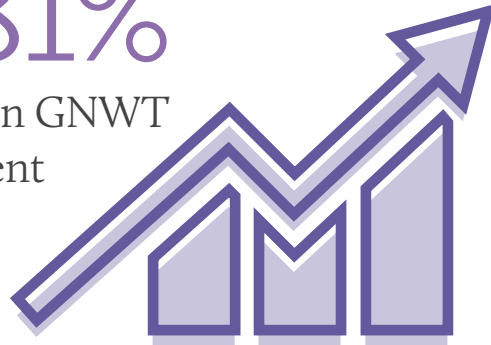
15

universities



1081%

Return on GNWT
investment



Graduate employment

30%

industry

37%

academia

24%

government



1.4M

square kilometres of
boreal forest and
tundra research area



Yellowknife Office and Territorial Connections



OVER THE PAST 10 YEARS, Laurier has developed its national and international leadership in cold regions research. Laurier was recently successful in partnering with the University of Saskatchewan in accessing \$78 million over the next seven years to support Global Water Futures (GWF) through the Canada First Research Excellence Fund (<https://gwf.usask.ca>). The goal of GWF is to deliver risk management solutions to manage water resources throughout Canada where global warming is changing landscapes, ecosystems, and the water environment. More specifically, through GWF, Laurier will lead several research initiatives throughout the NWT, raising the profile of NWT contributions to research on a global stage.

To further assist in enhancing and broadening this important partnership and to support our growing capacity for research needs in the NWT, Laurier has established a research office in downtown Yellowknife. The office includes full-time researchers and technical support staff, and serves as a base for graduate students involved in research. Having full-time Yellowknife-based personnel allows for year-round fieldwork, and the ability to build deeper relationships with Laurier's partners in the NWT. A year-round presence in the region allows us to more effectively work with all Government of NWT departments and agencies and communities throughout the NWT in supporting their present and future research needs.



Laurier highly qualified personnel in Yellowknife year-round

RYAN CONNOR was born in Behchokq' and returned to the NWT with a doctorate in geography and environmental studies in 2017, earned through working with Dr. William Quinton at the Scotty Creek Research Station. Dr. Connor's research focused on how permafrost thaw is changing the landscape – specifically, how water is cycled and stored. Over the last few decades, stream flow has increased significantly in the Scotty Creek area, and the research team at Scotty Creek have been able to show it is primarily due to changes in surface and subsurface water flow. Connor's doctoral work in this area won Laurier's Medal for Academic Excellence in 2017.

In September 2017 he became the Senior Research Associate Hydrometeorology at Wilfrid Laurier University's Yellowknife Research Office, the base for Laurier's growing team of northern-focused researchers. In November 2018 Dr. Connor transitioned to a new role as a Hydrologist in the Water Resources Division of Environment and Natural Resources within the Government of the Northwest Territories (NWT), enriching the communication between Laurier's research scientists in the field, government decision makers, and local communities.

Pan-Territorial Projects

Project	Research Location	Project Description	Contact
Northern water futures	Pan-territorial	Consortium of knowledge producers, mobilizers and users from communities, government, industry, non-governmental organizations and universities, working collaboratively to understand, predict and address the impacts of climate change and industrial expansion on shared water resources across the NWT.	Jennifer Baltzer
Integrative wildfire research program	Sahtú, Dehcho, Tłı̨chǫ	Understanding rates of forest recovery following wildfire, with applications for wildlife, forest, fire, and land use managers.	Jennifer Baltzer
Latitudinal gradients in forest response to climate warming and permafrost thaw	Scotty Creek, Havikpak Creek, Trail Valley Creek, Wrigley, Baker Creek, NWT; Wild Boy Creek, BC; Prince Albert, SK	A network of sites has been established where growth and water and carbon use are quantified at the tree and stand level. This will inform our understanding of climate change impacts on forest productivity.	Jennifer Baltzer Oliver Sonnentag
Mining impacts on wetland vegetation and implications for restoration	Giant Mine, Tundra Mine, Colomac Mine	Quantifying effects of mining activities on wetland vegetation and mycorrhizal fungi; Assessing success and analyzing options for restoration efforts.	Kevin Stevens
Development and application of ground freezing systems	Yellowknife Airport, Km 304 Highway 3, ITH, Norman Wells Airport	Applying customized ground freezing systems to reduce damage to infrastructure caused by permafrost thaw.	Bill Quinton
Global Water Citizenship: Enhance integration of citizen science data into environmental change research	Communities involved with community-based water monitoring	Building on existing citizen networks to design, test, and build data quality assessment and decision-support tools to better integrate citizen data with large-scale hydrological modelling.	Colin Robertson
Interpreting water quality monitoring data for potential effects	Communities involved with community-based water monitoring	Interpreting data for potential effects and examining strategies for adjusting water quality data for the bioavailability potential of metals.	James McGeer Scott Smith Kelly Munkittrick
Pan-territorial assessment of snow water equivalent (SWE)	Data review	Collaborating with GNWT, using historical data to determine how snow accumulation patterns are changing and effect this may have on basin runoff.	Ryan Connon Shawne Kokelj Bill Quinton
Improved characterization of permafrost vulnerability to support decision makers, infrastructure, and community stewardship	Sahtú, North Slave and Dehcho regions	Development of improved models to predict ground ice content with a view to assessing permafrost vulnerability to thermokarst at regional scales.	Jennifer Baltzer Merritt Turetsky
Estimating current and future carbon storage in the forests and wetlands of the NWT	Pan-territorial	Establish baseline forest and wetland carbon stocks and rates of carbon storage across the NWT, including proposed protected areas and use scenarios related to changing climate, disturbance and land use to explore the future of NWT forest/wetland carbon sequestration over time.	Jennifer Baltzer Merritt Turetsky
Northern research leadership camps	Dehcho, Tłı̨chǫ and Inuvialuit	To engage Indigenous NWT youth in hands-on science learning activities to build interest and skills in the scientific study of the impacts of land use and climate change on water and ecosystems in the North.	Jennifer Baltzer Andrew Spring

Pan-Territorial Research

GLOBAL WARMING IS DRIVING intensification of the wildfire regime in the boreal forest, which is resulting in shifts from coniferous to deciduous-dominated forests in some parts of boreal North America. This shift can present consequences for forest structure, ecosystem dynamics, carbon cycling and wildlife habitat. In 2014, an unprecedented 3.4 M hectares of boreal forest burned in the Northwest Territories (NWT).



Understanding how wildfire mediates soil communities and the impacts on post-fire forest regeneration

Nicola Day, PhD, Postdoctoral Fellow (2016–present), Baltzer Forest Ecology Research Group, Wilfrid Laurier University

As part of Northern Water Futures (NWF), we are undertaking a data synthesis of the long-term data that has been collected at the Daring Lake Research Station to understand the impacts of climate change on plants, soil and tundra for wildlife habitat. The focus has been leading field and data analysis components to understand the rates of forest recovery after the 2014 fires in the NWT. Understanding the role that global change processes and disturbance have on plants and soil microbes, with a focus on changes over time, is important for understanding the impacts of climate change on boreal forests and tundra on the Taiga Plains and Taiga Shield.



Recovery of ground vegetation following severe wildfire

Alison White, MSc (2015–18)

Supervisor: Dr. Jennifer Baltzer (Laurier)

Understanding the patterns of early recovery of plant communities is of interest both for humans and wildlife that depend on self-recovery of vegetation. We found that plant community recovery in the southern boreal forest of the NWT is rapid and dominated primarily by rhizomatic species present pre-fire. Responses were variable but we found that poorly drained areas with greater surficial moisture and associated soil characteristics strongly supported self-replacement of plant communities.



Plant trait variability of boreal forests along a latitudinal climate and permafrost gradient

Nia Perron, PhD Candidate (2018–present)

Supervisors: Dr. Oliver Sonnentag (Université de Montréal) and Dr. Jennifer Baltzer (Laurier)

This study aims to determine the role of boreal tree species (i.e., black spruce and larch) in the movement of water from the soil to the atmosphere through the process of transpiration. I am also interested in the impact that individual tree height, shape and dominance has on the seasonal transpiration of these trees. This research will repeat at multiple sites across northwestern Canada, from the southernmost edge of the boreal forest to the northern treeline. With this information, I will be able to determine the contribution that boreal tree species make to the total movement of water from the northern boreal forest ecosystem into the atmosphere. This research will help local areas understand how their boreal forests will respond to changing climate conditions.

Pan-Territorial Research



Forest regeneration following the 2014 NWT wildfires

Kirsten Reid, MSc (2015–2017)

Supervisor: Dr. Jennifer Baltzer (Laurier)

Both pre-fire black spruce-dominated and pre-fire mixed stands showed a significant decrease in black spruce relative abundance and an increase in the proportion of jack pine after fire. Differences in post-fire establishment patterns were seen across the Taiga Plains and Taiga Shield, suggesting that the two areas are responding differently to altered disturbances because of climate change. Stands that experienced a less severe burn had more viable seeds. This has implications for regeneration processes such as reduced recruitment rates. These results can inform ongoing modelling efforts to determine how future changes to this landscape will modify forest composition, wildlife habitat and forest processes.

Research Informs Global Climate Monitoring Network

IN 2013 THE SCOTTY CREEK FOREST DYNAMICS PLOT, located in the Hay River Lowlands, became part of the ForestGEO Global Earth Observatory Network. The site is the sentinel for boreal forest and permafrost changes for the entire network. Rajit Patankar, PhD, a postdoctoral researcher supervised by Dr. Jennifer Baltzer, worked to ensure that the data collection at the site facilitates global comparisons of forest change. His work at this site also demonstrated that permafrost conditions can impact the nature of plant responses to the animals that eat them. He also demonstrated the dramatic reduction in sap flow that occurs in the face of permafrost thaw.

The 21 hectare site contributes to worldwide scientific knowledge about forests and forest changes in the North, as it is the first and only boreal tundra woodland site with discontinuous permafrost features across the global network of 67 sites, across 27 countries. The site has 11 of the 12,000 tree species that are represented globally in the study. This long-term monitoring of the world's forests allows for global comparisons as the data collected is made available to scientists worldwide to monitor global climate change.



Boreal Forest Dynamics – Trees and lichen

CANADA'S NORTHERN BOREAL FOREST has faced significant climate warming over the past 100 years. This temperature change can have both direct and indirect effects on forest dynamics, including altering the disturbance patterns of herbivores and changing the abundance of natural enemies, competitors and mutualists.



Boreal forest response to permafrost thaw

Katherine Dearborn, PhD Postdoctoral researcher (2018–present)

with Dr. Jennifer Baltzer (Laurier)

My project examines the ways in which permafrost thaw is impacting the boreal forest on a 10-hectare forest plot established in 2013 south of Fort Simpson. Every tree in the plot was measured, mapped and identified to species, and permafrost depth was measured regularly throughout the plot. In 2018, I revisited all of the trees in the plot, recorded whether they were alive or dead, measured and mapped all new trees, and re-measured permafrost depth. By the end of 2019, all 135 smaller forest plots established throughout the territory in the early 2000s by the GNWT will have been recensused. By analyzing past forest responses to permafrost thaw, we will be able to better predict what the forest will look like in the future. It is important to be able to make accurate predictions about the forest so that northerners and northern stakeholders are able make informed decisions with respect to wildlife and resource management.



Estimating forage lichen biomass recovery in forest stands of Northwestern Canada

Geneviève Degré-Timmons, Technical staff (2016–present)

Supervisor: Dr. Jennifer Baltzer (Laurier)

Lichens are an essential food component for caribou, and many lichen species take decades to recover substantial cover and depth after severe disturbance such as wildfire. The boreal shield of Saskatchewan, the Taiga Plains and Taiga Shield of the Northwest Territories rank among the ecozones with the shortest fire return intervals in Canada. Accurately predicting lichen abundance in forest stands is important for understanding requirements and the effect of disturbances on lichens. This project will contribute to forecasting of caribou habitat quality with the expected increases in fire activity following on climate warming. These results are being used to enable better predictions of future landscape condition in terms of lichen biomass and vegetation type.



Growth dynamics of black spruce across Northwestern North America

Ana Sniderhan, PhD (2012–17), Global Water Futures (GWF)

Supervisor: Dr. Jennifer Baltzer (Laurier); Research Associate (2017–present), Ecosystem Resilience

Black spruce plays a critical role in helping mitigate climate change, as well as serving as key habitat for a variety of northern wildlife. This project investigated several aspects of the growth trends in black spruce across its latitudinal extent in Western Canada using tree-ring records. This study broadened our understanding of how a key northern tree species has responded to several aspects of a changing climate. This allows us to make predictions about how we might expect to see the boreal forest change as warming continues.

Boreal Forest Dynamics – Water flux



Environmental change in the NWT: Arctic and subarctic data synthesis

Anna Coles, PhD Postdoctoral researcher (2017–18)

with Dr. Jennifer Baltzer (Laurier)

My work encompasses several projects focused on understanding the mechanisms of climate-driven environmental change across geological, permafrost and climatic gradients of the NWT through using high-resolution remote sensing products for permafrost change detection in the North Slave and Sahtú, and an analysis of climate-change-driven environmental changes and geohazard occurrence around the NWT's 33 communities. We are also working to understand how permafrost thaw is affecting boreal tree water uptake regimes using stable water isotope analysis, and understanding flood risk from both ice jam and rainfall events in eight NWT communities to identify research and monitoring needs for effective prediction. This work will provide outputs useful for the implementation of effective, community-specific climate change adaptation measures.



Boreal tree water use dynamics across a latitudinal climate and permafrost gradient in Northwestern North America

Christoforos Pappas, PhD Postdoctoral researcher (2015–present)

with Dr. Oliver Sonnentag (Université de Montréal), Dr. Jennifer Baltzer (Laurier)

My research focuses on monitoring boreal tree water use and functional traits to better characterize tree-level carbon, water and energy dynamics. We have initialized field observations of tree water use and leaf functional traits at five boreal forest sites along a 2,000-km latitudinal climate and permafrost gradient, from permafrost-free, sporadic, discontinuous to continuous permafrost. This allows us to obtain quantitative insights of boreal tree functioning and plasticity to different environmental conditions. This work allows for a detailed quantification of boreal tree inter- and intra-specific variability and a better understanding of boreal forest resilience and plasticity to ongoing environmental changes.



Improving the boreal forest productivity estimates across Northwestern Canada

Bo Qu, PhD Candidate (2017–present)

Supervisor: Dr. Oliver Sonnentag (Université de Montréal)

We are studying boreal forest productivity estimates for northwestern Canada by improving the land surface component of the Canadian Terrestrial Ecosystem Model (CTEM), coupled to the Canadian Land Surface Scheme (CLASS). This work primarily involves stand-level testing and refining the current model against ecosystem carbon, water and energy fluxes from different permafrost-free (southern old black spruce and southern old jack pine) and permafrost (Scotty Creek) boreal forest sites across northwestern Canada. This work would reduce the current uncertainties and challenges in quantifying the multiple effects of climate change on the boreal forest and help forest managers develop effective strategies to adapt to the impending changes.

Boreal Forest Dynamics – Carbon cycling

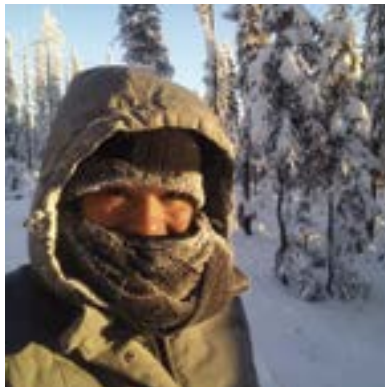


Impact of soil freeze-thaw cycles on the net carbon uptake period in boreal forests

Mariam El-Amine, MSc (2018–present)

Supervisor: Dr. Oliver Sonnentag (Université de Montréal)

This study will evaluate the impact of soil freeze-thaw cycle variations on the net carbon uptake period and the possible lagged effects on the annual net ecosystem productivity. Soil freeze-thaw cycles will be compared to the timing of phenological events to assess what indicator explains most of the variability of the net carbon uptake period. To evaluate spatial variability, results from sites at the southern limit of the boreal forest will be compared to the ones from the Scotty Creek site.



Spatial variability in net ecosystem CO₂ exchange across the NWT

Miriam Hurkuck, PhD Postdoctoral researcher (2017–18) with Dr. Phillip Marsh (Laurier), Dr. Oliver Sonnentag (Université de Montréal) and Dr. Elyn Humphreys (Carleton University)

The project focuses on a better understanding of high-latitude carbon dioxide (CO₂) fluxes and their rapidly changing biotic and abiotic controls in response to increasing natural and anthropogenic pressures. The study area consists of a latitudinal climate (maritime, continental) and permafrost gradient (sporadic, discontinuous, continuous) in northwestern Canada. It includes ten high-latitude research sites across the southern Arctic ecozones in the NWT. This study explores the impact of permafrost thaw and associated wetland expansion on boreal forest carbon and water budgets as well as the relative importance of tree line advance in comparison to shrub proliferation on tundra carbon and energy budgets. This research will help to understand the resilience of high-latitude tundra and boreal forest to environmental changes from natural and anthropogenic pressure.



Characterizing carbon stocks in the NWT to support protected areas planning

Kathe Todd-Brown, PhD Postdoctoral researcher (2018–present)

with Dr. Jennifer Baltzer (Laurier), Dr. Merritt Turetsky (University of Guelph), Dr. Steve Cumming (Laval University)

Although wetlands occupy only 4-6% of the earth's land area, they are estimated to contain 20-25% of the world's organic soil carbon, with the majority of this carbon stored in thick soils. Thus, while both forests and wetlands play important roles in global carbon cycling, the nature of their carbon stocks and sensitivities to disturbance and land use are likely to differ considerably. This project will estimate current forest and wetland carbon stocks and will develop methods by which future storage can be estimated for the NWT. This information will be useful for protected areas planning in terms of assessing the potential impacts of climate change and land use on carbon stocks, potential approaches to mitigate these impacts, and the potential for enhancing carbon sequestration or long-term removal of greenhouse gasses from the atmosphere. It will serve as a starting point for local communities, businesses, or governments to think about the potential for NWT-specific carbon mitigation projects.

North Slave Projects

Project	Research Location	Project Description	Contact
Contribution to the marian watershed stewardship program	Marian Watershed	Establishing baseline conditions and trends for contaminants and climate for a community-based aquatic ecosystem monitoring program.	Brent Wolfe
Sub-arctic metal mobility study (SAMMS)	Yellowknife - Whatì	Field, laboratory, and modelling studies to identify, quantify, and predict mobility of natural source and legacy mine-source metals in headwater catchment-lake systems.	Brent Wolfe Jason Venkiteswaran Michael English
Hydrological drivers producing surface runoff in unregulated catchments	Snare River system	Understanding flow levels in response to 2013–16 drought period, which increased expenditures on use of diesel fuel to generate electricity in Yellowknife and area.	Michael English Jennifer Hickman
Yellowknife local food strategy (NWF)	Yellowknife	Supporting local food strategy development through Yellowknife Food Charter Coalition based on food systems approach.	Andrew Spring Alison Blay-Palmer
The effect of dissolved organic carbon from permafrost thaw on drinking water	Wekweètì	Understanding how permafrost thaw alters dissolved organic matter and solubility/mobility of metals, which effects drinking water and ecosystem health.	Sherry Schiff Michael English Pieter Aukes Paul Dainard
Shifts in winter foraging grounds of the Bathurst caribou herd (NWF)	Wekweètì; NW of Winter Lake in the Snare-Coppermine basin tree line – tundra area	Examining the impact of changing snow conditions and Arctic Oscillation on winter foraging behaviour of Bathurst caribou and how that relates to the winter shift in foraging grounds from boreal forest to tree line-tundra area.	Michael English Colin Robertson
Understanding impacts from combustion byproducts and dust on barren ground caribou	Literature review	Exploring impact of mine source dust and diesel combustion on vegetation and barren ground caribou to improve management of mining dust.	Jennifer Hickman Michael English
Improving road sub-grades to reduce damage due to permafrost thaw	Yellowknife area	Examining subsurface temperatures and ground surface displacement for a range of sub-grade materials used below roads in the NWT. This will provide guidance for optimal road materials to given environmental conditions and road use.	Bill Quinton Susan Tighe
Assessment of stress effects related to arsenic contamination and remediation at Giant Mine	Yellowknife, Ndilq and Dettah	Assessing sources, levels, and ways of coping with psychological stress related to historical and current activities at the Giant Mine site. This will inform on-going remediation and empower communities to address sources and consequences of stress.	Ketan Shankardass

North Slave Projects – Food security



Food systems and innovative governance

Carla Johnston, PhD Candidate (2018–present), MA (2016–2018)

Supervisors: Dr. Peter Andr  e (Carleton University, MA) Dr. Alison Blay-Palmer, Dr. Andrew Spring (Laurier)

My research includes the governance of sustainable food systems in northern Canada using Participatory Action Research (PAR) methodology to work directly with local actors to create meaningful actions that help them reach their goals. I partnered with Ecology North to host the Yellowknife Fall Harvest Fair for two years as well as to develop the NWT Food Network, a collaboration of food system actors and community leaders that seeks to nurture and promote food systems in the NWT. This Network is an extension of my Masters research that worked with the Yellowknife Food Charter Coalition to make the case for a local food strategy with the City of Yellowknife, using a food systems approach. A food systems approach reflects the awareness of how actions by one group in the system affects other groups. This includes the coordination and collaboration of actors throughout the food chain, including government decision-makers, to create integrated solutions. This engagement included working with the Food Charter Coalition to establish their research needs relating to community-led policy initiatives and well as establishing a direct-action Supper Club program with other community organizations.



Northern food systems research

Molly Stollmeyer, Research Assistant, Laurier Centre for Sustainable Food Systems (2018-Present); MA (2018-present)

Supervisors: Dr. Peter Andr  e (Carleton University), Drs. Alison Blay-Palmer, Dr. Andrew Spring (Laurier)

Collaboration plays an important role in fostering local food systems in the North. Leading to this graduate work, I worked alongside staff from Dechita Naowo, Yellowknives Dene First Nation (YKDFN) organizing the annual Fall Harvest Fair. This year's change in location was significant as it brought Yellowknife residents together with both YKDFN communities, Ndilo and Dettah, on their common ground along the Yellowknife River. The fair has its roots with the Yellowknife gardening community, and this was the fourth year that Ecology North and Laurier collaborated with YKDFN in celebration of local food and harvest.

I also helped to facilitate a Supper Club hosted at Hope's Haven and Centre for Northern Families through a collaboration with the Yellowknife Farmers Market and Anti-Poverty Coalition. I offered support to a newly formed NWT Food Network, by digging up archived agricultural records to find evidence of the immense capacity for agriculture across the territory. I have worked to foster collaboration between multiple actors including research institutions, Indigenous community programs, not-for-profit organizations, public markets, food producers and many more.

North Slave Projects – Monitoring



Defining a legacy pollution footprint: assessing spatiotemporal patterns of arsenic and other metals in subarctic lakes using paleolimnology

Izabela Jasiak, MSc (2018–present)

Supervisors: Dr. Roland Hall (University of Waterloo), Dr. Brent Wolfe (Laurier)

Concerns about arsenic in the Yellowknife area have persisted because of toxic dust released into the atmosphere during the gold extraction process at nearby Giant Mine. While many have studied ‘contemporary’ effects of ore roasting on lakes close to Yellowknife in the form of lake water and surficial sediment surveys, uncertainties exist about the spatial extent of Giant Mine’s emissions.

We are addressing this knowledge gap using sediment cores collected from lakes along an 80-km transect at 10-km intervals downwind of Giant Mine to reconstruct past arsenic deposition and to identify how changes in climate may influence release of arsenic into aquatic ecosystems.

This knowledge will give natural resource managers and governments an understanding of the area of land and water that is storing legacy pollution that may continue to affect ecosystems.



Using paleolimnology to establish sediment quality baselines for a community-led aquatic monitoring program, Tłı̨chʼı̨ Lands, NWT

James Telford, MSc (2015–18)

Supervisors: Dr. Brent Wolfe (Laurier), Dr. Roland Hall (University of Waterloo)

To address community concerns about climate change and the potential impacts of future mining development, the Tłı̨chʼı̨ Government started the Marian Watershed Stewardship Program (MWSP) to monitor water, sediment and fish at many locations throughout the watershed. Sampling locations are chosen through consultation with Tłı̨chʼı̨ elders and scientists focusing on areas that are culturally and scientifically important. In collaboration with the MWSP, we have used sediment cores taken from multiple lakes to understand how sediment metal concentrations have changed naturally over hundreds of years at these locations. The MWSP can continue to assess for potential future mining pollution at these locations by comparing this baseline sediment metals dataset to surface sediment samples. Results from sampling are presented at yearly Tłı̨chʼı̨ community workshops.

Yellowknife Fall Harvest Fair

LAURIER'S INVOLVEMENT in the Yellowknife Fall Harvest Fair evolved out of a long-term partnership and collaboration with Ecology North to work on food security research in the NWT. The Fall Harvest Fair is an annual event to bring the Dettah, Ndiłı̨ and Yellowknife communities together in celebration of local food and harvests. The event is held in collaboration with Ecology North, Yellowknives Dene First Nation and Yellowknife Community Garden Collective. Since 2014, multiple graduate students associated with the Laurier's Centre for Sustainable Food Systems and Food: Locally Embedded, Globally Engaged (FLEdGE) SSHRC Partnership Grant have engaged in food security research through the Laurier – Ecology North partnership to support local food initiatives in Yellowknife. In 2015 Laurier doctoral student Andrew Spring initiated the ground work to support the Fall Harvest Fair and in 2016 and 2017 Masters student, Carla Johnston, played a leading role in coordinating the event as part of her food systems research in Yellowknife. In 2018 Molly Stollmeyer continued this work and will return to support the event in 2019. For the past four years, FLEdGE and Laurier have supported the Fall Harvest Fair financially as it is an important event for our partners and communities.



North Slave Projects (continued)

Collaborating to augment a community-led aquatic ecosystem monitoring program

INITIATED BY Thjichq Government's Marian Watershed Stewardship Program (MWSP), Laurier professor Brent Wolfe was contacted in 2014 to contribute to their aquatic ecosystem monitoring efforts. They were concerned about pollution from proposed mining in their Traditional Territory. Soon after, James Telford, an MSc student supervised by Wolfe and co-supervised by Professor Roland Hall of the University of Waterloo, began working closely with the Thjichq. James participated in MWSP field sampling trips in 2015-17, where he trained MWSP members in sampling techniques. Sampling sites were selected through consultation with the Thjichq and focused on areas culturally and scientifically important. This collaborative effort created excellent opportunities for knowledge sharing. Results have established long-term baseline conditions of sediment metals concentrations in lakes. These sites can be monitored now and in the future to assess for pollution. The success of this project demonstrates the strengths and benefits of combining Thjichq traditional knowledge and northern scientific research to augment a community-led monitoring initiative.



Quantification of hydrological mass balances of rivers supplying hydroelectricity

Jennifer Hickman, MSc (2012–15); Research Associate, Water Quality, Yellowknife Office (2017–present)

Supervisor: Dr. Jason Venkiteswaran (Laurier)

The Snare River watershed supplies hydroelectric power to over half the population of the NWT. Drought in the last two decades, most recently in 2014-2015, has made it increasingly difficult and sometimes impossible to generate power. This work aims to quantify the hydrological mass balance of an unregulated sub-watershed in the upper portion of the Snare basin. By doing so, patterns in basin conditions can be evaluated and the recovery time of the basin after a drought can be analyzed.

I am also working on the Sub-Arctic Metal Mobility Study (SAMMS) project, with support from the Thjichq and Yellowknives Dene First Nations. SAMMS is a GWF-funded project based near Yellowknife, focused on arsenic deposition on the landscape from the operation of Giant Mine. My role has been to support research initiatives, including designing experiments, installing field instrumentation, collecting water samples, and supporting the development of Master of Science student projects.



Near-surface ground ice of boreal forests in discontinuous permafrost

Jason Paul, MSc (2016–18)

Supervisor: Dr. Jennifer Baltzer (Laurier), Dr. Steve Kokelj (NWT Geographic Survey)

This study examined how ground ice content differs between the two most common forest types in the Yellowknife area – black spruce and white spruce/birch. The vertical structure of ice and its variability within forest stands was characterized within a 30-km radius of Yellowknife, which helps us understand how these systems will respond to thawing. Sites with deeper permafrost showed signs that the continued vertical thaw and eventual disappearance of permafrost is already beginning in some white spruce/birch stands in the Yellowknife area. This work will help predict the potential for landscape change as a result of permafrost thaw in this area as climate warming continues. In addition, a better understanding of the variability of ground ice content in these two main forest types will help assist in infrastructure development planning to avoid building on land with ice-rich permafrost that would be at risk of thaw and subsequent damage to infrastructure due to human disturbance.

North Slave Projects (continued)



Changes to the spatial and temporal fall and winter foraging areas of the Bathurst caribou herd between 1996 and 2016 and how that relates to changes in snowpack water equivalent

Nick Wilson, MSc (2015–present)

Supervisor: Dr. Michael English (Laurier)

My research focuses on quantifying the Bathurst caribou herd fall and winter home range and monitoring caribou migration since 1986 using data from ENR of the GNWT. Over the last 20 years, the Bathurst caribou herd's population has declined significantly, from approximately 400,000 individuals in 1996 to (according to an ENR survey) an estimated 15,000 individuals in 2015. The cause of this decline is not well understood as it is a complicated issue involving food availability, predation, overharvesting and changes in climate. The amount and density of snow on the ground can impact caribou movements and the energy they expend to gather food. Using collared caribou data, it is possible to determine the specific location of individuals at a given time and relate these spatial patterns over time to changes in snowpack water equivalent (SWE) as determined using satellite imagery data.

Daily records of SWE from 25km resolution pixels are available from the SSM/I satellite series dating back to 1979. Fieldwork conducted in the Wekweeti region during the winter months helps verify the satellite data. Relating caribou location to SWE in this way will allow us to discern how snow may play a role in their migratory patterns. Preliminary findings indicate that after 2005, the Bathurst herd caribou were establishing winter foraging grounds near and above the tree line when previously their winter foraging grounds were located well to the south in the boreal forest. These findings will contribute to understanding how SWE may play a role in determining the winter foraging areas of the Bathurst caribou herd.



Dehcho Projects

Project	Research Location	Project Description	Contact
Consortium for permafrost ecosystems in transition (CPET)	Scotty Creek, Suhm Creek, Jean-Marie River, Calendar Creek, 12 remote sensing sites	Improving understanding and prediction of water flow and storage processes in the thawing, peatland-dominated southern fringe of discontinuous permafrost.	Bill Quinton
Hydrological and thermal function of mineral soil uplands	Birch River	Quantifying the flux and storage of water and energy through mineral soil uplands in low relief, discontinuous permafrost terrain.	Ryan Connon Bill Quinton
Arctic fire	Scotty Creek	Examining the impact of wildfires on peat, runoff processes and pathways, and the quality of water draining to downstream ecosystems.	Bill Quinton
Dehcho K'éhodi needs and assets inventory	Dehcho	Generating shared knowledge about the community's capacity to engage in land and water stewardship and build greater capacity.	Alex Latta



Forming Lasting Connections in Fort Simpson

THE FORT SIMPSON LITERACY PROJECT was an initiative of Elzbieta Mastej, a master's student with Laurier's Cold Regions Research Centre, supervised by Dr. William Quinton. Encouraging literacy within the context of Indigenous culture was identified as a community priority within the school. In 2018, a small grant was obtained through Laurier to deliver a short workshop with pre-school children at Bompas Elementary School. These experiences and connections will contribute to the richness of Laurier's community engagement initiatives – perhaps one day these children will participate in Dehcho Guardians training offered through Laurier or participate in the Scotty Creek Field School. The hope is that this educational program can be offered again in Fort Simpson and potentially incorporate a few Dene Zhatié (South Slavey) words from the local Indigenous language.



Dehcho Projects



Mercury biogeochemistry in thawing permafrost landscapes

Kevin Ng, PhD Student (2017–present)

Supervisors: Dr. B. Branfireun (Western University), Dr. William Quinton (Laurier)

In the Dehcho Region of the NWT, there are some lakes with consumption advisories due to mercury levels in fish. This study investigates the rate at which methylmercury is produced and broken down in areas of thawing permafrost. As climate change accelerates this thaw, changes in landscape and hydrology may favour the production of methylmercury. Samples of peat and water will be collected across multiple thawing permafrost wetlands during different seasons and years to determine the connection between the production of methylmercury and its transport to downstream areas. This work will assist in providing information to better understand and predict whether methylmercury produced in these areas may lead to increases levels found in fish in northern lakes.



Permafrost thaw-induced changes to runoff generation and hydrologic connectivity

Ryan Connon, PhD (2013–17), Research Associate, Hydrometeorology

Supervisor: Dr. William Quinton (Laurier); (2017-18)

Understanding the controls on subsurface water fluxes and how they may continue to change in the future is critical to predict and mitigate the impacts on infrastructure. Further south, in the zone of discontinuous permafrost, incomplete refreeze of the active layer yields a layer of unfrozen, saturated material (talik) that promotes the year-round subsurface movement of water and energy. Permafrost thaw in this discontinuous zone is widespread and of great concern to communities in the NWT's Dehcho region. Techniques to describe current permafrost distribution, predict future distribution and mitigate potential thaw are being developed in partnership with other Laurier researchers and First Nation partners.



Changes in plant community composition, structure, and function in response to permafrost thaw

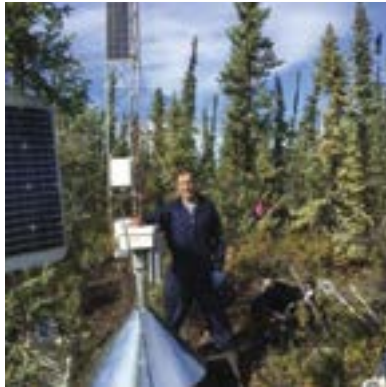
Katherine Standen, PhD Candidate (2016–present)

Supervisor: Dr. Jennifer Baltzer (Laurier)

Rapid climate change in northern Canada is leading to increased air and soil temperatures, changing precipitation cycles and permafrost thaw. Thus, a changing climate may modify the quantity and quality of resources available to plants. Specifically, permafrost thaw has been shown to alter the availability of nutrients and water in the soil and thus could lead to changes in plant traits in this region. I am studying how permafrost thaw and the associated increase in nutrients are influencing plant traits in the boreal forest, especially how environmental change is altering plant traits related to carbon uptake. My focus on traits related to carbon in the boreal is critical, as the boreal forest stores approximately 1/3 of global carbon and the release of this carbon to the atmosphere could further hasten global climate change. My research will be included in models investigating current and projected changes in carbon cycling and the environment in northern Canada.

Effects on Infrastructure

TRANSPORTATION AND OTHER INFRASTRUCTURE in the NWT must not only be able to withstand harsh conditions, but also respond to changing land stability as permafrost thaws and recedes. Laurier research projects are measuring and analyzing these changes over time to predict the effect of permafrost changes on infrastructure.

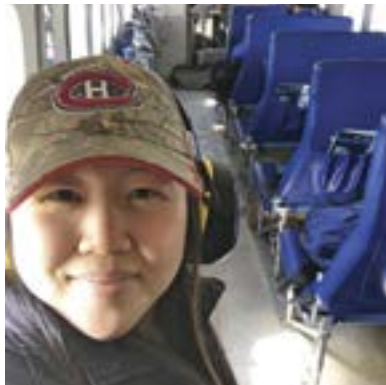


Development and testing of ground freezing systems for permafrost thaw mitigation

Igor Egorov, PhD Candidate (2018–present)

Supervisor: Dr. William Quinton

I am a research scientist with the National Research Council (NRC), Ottawa, on leave to develop and evaluate advanced permafrost restoration and thaw mitigation systems and permafrost restoration, and determine the effectiveness of such systems in the protection of transportation infrastructure. Many sections of northern highways are at high risk of instability due to ground temperature increase and thaw of ice-rich ground. Increasing occurrence of standing depressions adjacent to highways creates extra groundwater flow and heat advection, causing additional permafrost thaw in the highway subgrade. These impacts, including differential settlements and shoulder instabilities, are significantly increasing not only the highway operating and maintenance costs but also the risk of highway failure.



Permafrost degradation in road subgrades due to climate change

Michelle Liu, MSc (2018–20)

Supervisors: Dr. S. Tighe (University of Waterloo), Dr. William Quinton (Laurier)

This study aims to quantify permafrost degradation beneath sections of the Inuvik Tuktoyaktuk Highway (ITH) by calculating the decline of permafrost table and reduction in permafrost active layer thickness (ALT) from existing data. The results will be analyzed against pavement temperature data of the corresponding ITH sections to determine whether a correlation is present. Permafrost table and ALT data of nearby natural ground will also be analyzed against the same set of pavement temperature data as baseline for verifying the significance of the correlation.



Investigating the effects of snow cover on ground thermal regime at the seismic line and evaluation of thermosyphon performance

Elzbieta Mastej, MSc (2017–present)

Supervisor: Dr. William Quinton (Laurier)

This study investigates the effects of snow cover on ground thermal regime and consequently permafrost fate at the seismic line and evaluates the thermosyphon technology for its performance as a ground cooling device. This work is relevant to future resource exploration and concomitant infrastructure as well as future climate models. It is focused on the development of low cost, readily deployable ground cooling infrastructure that may serve to mitigate permafrost thaw by altering snow accumulation regimes in the rapidly warming southern Dehcho region.

Sensors



Development and testing of metal bioavailability sensors

Gill Gaganprit, PhD (2017–present)

Supervisors: Drs. Scott Smith, Dr. Jim McGeer (Laurier),

Dr. Juewen Liu (University of Waterloo)

Risk assessment tools used to predict the toxic form of a metal and associated toxic effect concentrations for different organisms have proven invaluable in appropriate assessment of metals risk in surface waters but they do require measurement of many different parameters. The probes I am developing will allow measurement of the toxic fraction of a metal directly and provide real-time data to allow water managers to make informed decisions without requiring additional time-consuming water chemistry surveys. These probes are based on specially designed DNA molecules that bind metals and generate electrochemical or optical signals proportional to metal bioavailability. Our first planned deployment of prototype probes will be at the Ptarmigan mine site outside of Yellowknife.





THE SCOTTY CREEK RESEARCH STATION (SCRS) is 50 kilometres south of Fort Simpson, Northwest Territories, Canada. Periodic snow field measurements at Scotty Creek began in 1994. In 1996, the Water Survey of Canada installed a stream gauging station at the Scotty Creek outlet, and in 1999 the first stations were installed in the basin headwaters for year-round data collection. The “Old Camp” was replaced by the First Lake Camp (2007-2012) and then by the Goose Lake Camp (2012-present). Since 2003, the Scotty Creek station has operated each year between mid-March and early September, and based on person-days, it is one of the busiest research stations in Canada’s North. It offers a unique opportunity for high-quality training and community engagement involving world-class expertise and state-of-art research infrastructure. The camp has experienced the effects of permafrost thaw first-hand over the years. In 2017, the infrastructure of the Goose Lake camp was upgraded to include a new power system and new high quality laboratory space.



The Hydrological effect of linear disturbances on bogs in the NWT

Angela Elgie MSc (2017–18)

Supervisor: Dr. William Quinton (Laurier)

In the search for resources in the boreal region, geological survey crews create seismic lines to allow access for equipment in previously undisturbed regions to scan the ground below. Permafrost underlies these northern grounds and is being degraded faster due to these disturbances. The focus of this work is to look at the effects a 1986 seismic line disturbance has on bogs with varying hydrologic connectivity to the disturbance at Scotty Creek Research Centre, NWT. Fully connected bogs are directly in the path of the seismic lines, semi-connected bogs are connected through channels, and isolated bogs appear to be unaffected by the disturbance. After some investigation through frost probing, it seems some of the isolated bogs are forming connections to the seismic line underground. To better understand how the seismic line affects bogs, this study will provide a comparison of the different characteristics of each bog. The study will aid in predicting future changes to the landscape, water storage, and vegetation. The information will prove useful when trying to map out water flow paths and to see if it is possible for the land used for seismic line activity to recover.



The impact of a low-severity burn on the trajectory of permafrost thaw: Scotty Creek, Northwest Territories, Canada

Elyse Mathieu, MSc (2015–present)

Supervisor: Dr. William Quinton (Laurier)

My research aims to improve the understanding of how a low severity-wildfire affects the thermal properties of the supra-permafrost layer in a wetland-dominated zone of thawing discontinuous permafrost that typifies much of the circumpolar subarctic. This is accomplished through a field study that monitored the impacts of a low-severity fire on key thermal and hydrometric variables over a one- to three-year period following the fire, and by the development of a new conceptual model that represents the major thermal and hydrometric processes and feedbacks affected by or that arise from a low-severity burn, and can be used to predict changes to the permafrost environment as a result of such a burn.

Scotty Creek Research Station (continued)



Investigating the impacts of microtopography and canopy cover on subarctic landcover changes in the discontinuous permafrost zone, Scotty Creek, NWT

Jessica Smart, MES (2018–present)

Supervisor: Dr. William Quinton (Laurier)

This research examines the relationship between organic sphagnum hummocks, black spruce and permafrost at Scotty Creek Research Station, NWT. Two primary objectives of this research include understanding seasonal development of ice bulbs as possible establishment of permafrost and determining the impact of black spruce canopy on hummock growth. By understanding the theoretical transformation and relationship between components of northern subarctic landscapes, we can offer predictions on future outcomes of these environments. This research will provide new knowledge needed to determine how northern landscapes are transitioning, which is valuable for predicting landscape trajectories. This study aims to determine whether permafrost aggregation is possible in a warming climate of the subarctic, through combining disciplines of ecology and hydrology.



Land-atmosphere interactions in thawing boreal forest-wetland landscapes of the NWT

Manuel Helbig, PhD (2013–17)

Supervisors: Dr. Oliver Sonnentag (Université de Montréal), Dr. William Quinton (Laurier)

This study explores how thaw-induced land cover change in the Scotty Creek watershed affects greenhouse gas exchange and energy and water fluxes. Additionally, the study quantifies the climatic impacts of these changes in land-atmosphere interactions. To address these questions, multi-year observations of land-atmosphere exchanges of greenhouse gases, water and energy were analysed. The results of this study improve our understanding of the role of thawing boreal landscapes in regional and global climate systems. This work is relevant to improve predictions of climate change and to better constrain regional water futures in the NWT. A better understanding of land-atmosphere interactions is important to inform evidence-based land management decision making and to inform policy makers about the consequences of land management practices.



Changes in extreme hydroclimate events in the southern NWT

Bhaleka Persaud, PhD (2013–present)

Supervisors: Dr. William Quinton (Laurier), Dr. Paul Whitfield (University of Saskatchewan)

This research focuses on analyzing extreme events using alternative datasets to understand historical changes in temperatures, precipitation and streamflow. This study will also investigate if these events are connected to large-scale climate teleconnections (e.g. Arctic oscillation) across the southern NWT. Improving our ability to understand how local climate and hydrology has changed, and how these will change in the southern NWT in the next 30-50 years, will also provide policy makers better information to improve existing adaptation and mitigation measures to combat climate change within local communities across the territory.

Scotty Creek Research Station (continued)

CLIMATE WARMING in peatland regions is often associated with the conversion of treed plateaus underlain by permafrost to treeless, permafrost-free bog features.



Modelling the effects of permafrost loss on discharge from a wetland-dominated basin in the discontinuous permafrost zone

Lindsay Stone, MSc (2015–17)

Supervisors: Dr. William Quinton (Laurier), Dr. John Pomeroy (University of Saskatchewan)

Very little is known about how water is stored and conveyed in channel fens, and as a result, it is very difficult to predict the impact of warming and permafrost thaw in vast areas of the southern NWT that contain these wetland features. I evaluated the impact of permafrost loss on discharge from Scotty Creek by modelling and incrementally changing the proportion of the landscape underlain by permafrost. This modelling exercise combined with intensive field observations demonstrated that permafrost reduction decreases the seasonal variability in flow through channel fens due to changes in the flow path routing, with amplified low-flows associated with small increases in subsurface discharge, and decreased peak discharge with large reductions in surface runoff.



Characterizing treed bogs across a sporadic-discontinuous permafrost landscape

Brenden Disher, MSc Candidate (2017–present)

Supervisor: Dr. William Quinton (Laurier)

The main objective of this work is to provide new insights regarding the future of permafrost-free landscapes in sporadic-discontinuous (10-50% ground cover underlain by permafrost) permafrost peatlands. Identifying how sporadic permafrost wetland complexes evolve under a warming climate represents an important step in better predicting changes to basin-scale hydrological and ecological regimes.

These changes can have important implications for infrastructure and local community land use in the north, and the resultant knowledge from this can be applied to science-based decision making for northern water resources.



Hydrological impacts of permafrost thaw-induced landscape change

Kristine Haynes, PhD Postdoctoral researcher (2017–19)

with Dr. William Quinton (Laurier)

Long-term records of water storage on permafrost plateaus, bogs and fens are examined to assess changes in water storage and flow processes across the varied environment of the discontinuous-sporadic permafrost zone in order to determine how landscape transition is affecting the hydrological mechanisms governing water storage and movement in this region. With continued landscape change as air temperatures continue to rise, it is important to understand the implications of these changes on both the availability and long-term sustainability of freshwater resources. The aim of this research is to inform water resource management policy to ensure continued availability of freshwater resources for northern communities.

Scotty Creek Research Station – Permafrost thaw acceleration

AS PERMAFROST THAW ACCELERATES, the corridors northerners navigate across the land are changing, with peat plateaus turning to wetlands and rivers having less predictable flow regimes. Infrastructure such as buildings and roads are at risk as the structural integrity provided by previously frozen soils is compromised, and greenhouse gas emissions may also increase where saturated organic rich soils were previously frozen.



Modelling permafrost thaw and groundwater flow

Joelle Langford, MSc (2016–18)

Supervisors: Dr. R. Schincariol (Western University), Dr. William Quinton (Laurier)

Permafrost covers about one quarter of the Northern Hemisphere and in many areas, it is rapidly decaying. My work aims to characterize the transitional period of permafrost decay using a three-dimensional mathematical model based on a thawing permafrost body at Scotty Creek basin in the Northwest Territories, Canada. The model simulations demonstrated the critical role that variations in land surface and permafrost table microtopography, along with talik development, play in permafrost degradation. The model simulations also allowed for the testing of remedial measures, such as mulching and borehole heat exchangers, to stabilize permafrost in high-value infrastructure environments.



Permafrost thaw-induced forest to wetland conversion: potential impacts on basin snowmelt runoff

Emily Haughton, MSc (2015–17)

Supervisor: Dr. William Quinton (Laurier)

Between 1977 and 2010, total areal snow water equivalent (SWE) decreased by 1.5 %, but the amount of SWE made available as runoff increased by 25%. Therefore, my research evaluates how permafrost thaw-induced wetland expansion at the expense of forest might affect the proportion of snowmelt that can contribute to basin runoff during the spring freshet of a 152 km² watershed in the southern NWT. The increased proportion of the snow cover that contributes meltwater to streams may be a factor contributing to the rising stream flows observed across the study region in the mid-1990s and early 2000s, given that there has been no concomitant increase in wintertime precipitation.



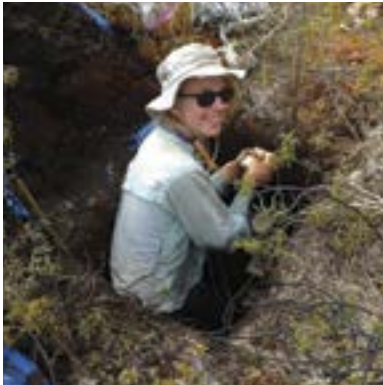
The impacts of climate change on permafrost distribution

Olivia Carpino, PhD (2018–present)

Supervisor: Dr. William Quinton (Laurier)

We are working to improve our understanding of permafrost distribution throughout Northwestern Canada's discontinuous permafrost zone. Understanding of the unique conditions contributing to permafrost distribution, especially at a higher resolution than current permafrost maps, is critical for studying permafrost environments and anticipating how the land will change in the coming years and future. Identifying areas that are more prone to thaw and predicting how they will behave in the future will provide valuable insight into these transitional and dynamic northern environments. Communities, those working on the land, and industry can use this information to make decisions surrounding development and resource management.

Scotty Creek Research Station (continued)



The changing influence of permafrost on peatlands hydrology

Élise Devoie PhD Candidate, (2016–present)

Supervisors: Dr. James R. Craig (University of Waterloo), Dr. William Quinton (Laurier)

The main objective of this research is to improve our ability to explain, quantify, simulate and predict hydrologic changes due to permafrost thaw in the discontinuous permafrost peatlands environment. Identifying thaw mechanisms in permafrost environments and representing them in a hydrological model will improve our ability to understand and predict hydrological impacts of climate change in these environments. The resulting thaw model can be used by industry in the development of durable infrastructure and lay a foundation for rigorous, science-based decision making on water resource management, providing information for legislation protecting water resources in cold regions.



Discerning subsurface flow-paths and water storage on a peat plateau in the discontinuous permafrost region

Mason Dominico, MSc (2018–present)

Supervisor: Dr. William Quinton (Laurier)

The variables that control thaw of the interior plateau and its fragmentation have not previously been studied. This project aims to create an energy balance of a stable permafrost body and identify factors that govern thaw rates on the interior of a plateau. By investigating the factors that affect thaw rates on the interior of a peat plateau and creating an energy balance for a 'stable' plateau, a better understanding of what the future holds for these landscapes can be gained.



Dehcho and South Slave Projects

Trajectory surveillance tools for boreal caribou conservation and management	South Slave and Dehcho	Finding new applications for modelling individual and population parameters from boreal caribou collaring data for conservation and planning needs.	Colin Robertson
Ka'a'gee Tu First Nation exploration of climate change, food security and health (NWF)	Kakisa	Establishing adaptation plan to ensure community food security and to build resilience through collaborative work.	Andrew Spring Alison Blay-Palmer
Ka'a'gee Tu Atlas: Community-based monitoring of landscape change (NWF)	Kakisa	Community-based mapping and monitoring project enabling community members record impacts of environmental change and developments on the land.	Andrew Spring Alison Blay-Palmer
Investigation into fish health and variable fish mercury concentrations in regional lakes (NWF)	Kakisa Lake Tathlina Lake	Surveying general health and mercury levels in fish in response to community questions regarding fish population status and variable mercury levels in regional lakes.	Deborah MacLatchy Andrea Lister Heidi Swanson
Dehcho K'éhodi community-based strategic planning	Kakisa Sambaa K'e	Supporting communities to conduct strategic planning for Dehcho K'éhodi land and water stewardship, including Indigenous Guardians.	Alex Latta
Climate change adaptation planning in Sambaa K'e and Ka'a'gee Tu	Kakisa Sambaa K'e	Conducting climate change planning, share knowledge, and determine research and monitoring needs to enhance community adaptation.	Ka'a'gee Tu First Nation (Laurier contact: Andrew Spring)
Northern agriculture futures: Adapting to a changing climate through agriculture	South Slave and Dehcho	Addressing barriers that may limit the ability of communities to take advantage of potential agriculture opportunities now, and into the future.	Ka'a'gee Tu First Nation (Laurier contact: Andrew Spring)

Mapping Knowledge on the Land

THE KA'A'GEE TU ATLAS, a project funded by the Government of the Northwest Territories' Cumulative Impact Monitoring Program (CIMP), emerged in response to the experiences of community members wanting to map and monitor changes to their lands due to the impacts of development and climate change.

In 2016-17 Masters of Science student Kaitlin Kok worked alongside Elders and knowledge holders to address these concerns by creating a series of maps with the community. Using photos of the past, voice recordings to tell stories, and mapping technology, Kok has been documenting the climatic changes to the land, based on the stories from Elders and traditional knowledge, and its impact on traditional food and community health.

The community has been adding to maps of trails and safe places by documenting potential hazards on the landscape to help them adapt to variable and unsafe conditions that are becoming more frequent with the impacts of climate change.

During her work with the community Kok engaged youth in several on-the- land experiences and taught students how to use mapping technology to document important locations, and record observations of plants, animals and culturally significant areas along their route.

Dehcho and South Slave Projects - Land Change and Fires



A mixed methods approach to understanding the way it “Used to Be” in a Dene Community in the NWT

Kaitlin Kok, MES (2016–18)

Supervisors: Dr. Alison Blay-Palmer and Dr. Andrew Spring (Laurier)

Working closely with the community of Kakisa, NWT, I have developed an online map that acts as a monitoring tool to identify and observe areas of change through community input. To understand some of the impacts climate change has on secure access to traditional food, focus groups and interviews were conducted with community members. Traditional knowledge was shared and community photographs were collected to identify changes and gather an understanding for how this tool can be effectively implemented. The map can be continuously added to by members of the community to document changes in landscape characteristics as a result of climate change. This work comes out of the desire to record environmental change and will serve as the community's database of observed changes. This has broader applications for the community when trying to identify patterns of change and address safety concerns when community members travel on the land.



Implications of low-severity wildfire on runoff water source and flowpath on a peat plateau in a wetland-dominated landscape at Scotty Creek

Caren Ackley MSc (2015–18)

Supervisors: Dr. William Quinton (Laurier), Dr. Suzanne Tank (University of Alberta)

In 2014, a low-severity wildfire burned approximately half of a 0.05 km² peat plateau within the Scotty Creek drainage basin. The study is comparing the unburned and burned portions of the affected plateau to quantify differences in runoff water chemistry, observe changes to the water and energy balances that affect the integrity of a permafrost plateau, and examine post-fire changes in runoff flowpath dictated by altered peat physical properties and seasonal thaw depth. Understanding the impacts of small, localized wildfires on landscape evolution and water resources will aid in decision making for emergency response and firefighting resources to minimize environmental impacts.



Sharing Fire and Forest Regeneration Research in Kakisa

FOREST FIRE is a direct concern for many NWT communities. In Kakisa, fire has impacted the community several times in the past. Dr. Jennifer Baltzer, Canada Research Chair in Forests and Global Change, is conducting forest fire regeneration research in the area around Kakisa that was burned in the fires of 2014 as part of an ongoing NWT Cumulative Impacts Monitoring Program (CIMP) project to determine “Impacts of wildfire on caribou habitat: from woodland to barren ground”. As part of this project, Alison White, a Master of Biological Sciences student, helped plan an event with the community school to take youth into the recently burned areas as well as unburned areas around community to teach the students about the impacts of fire and understand the regeneration processes of the boreal forest. Two community Elders participated in the event, identifying, sharing the Dene language names and traditional uses of plants with the students, and provided insights into what animals might come to the areas as the forest regenerates. Participating students built their own transects to count, identify and monitor what was growing in the forest.

Dehcho and South Slave Projects - Food Security and Waste

FOOD SECURITY IS A PRESSING ISSUE for indigenous communities in the NWT. Access to traditional food sources is threatened by factors such as climate change, and store-bought food is often expensive and out of reach for isolated communities.



Food security in Canada's north

Michelle Malandra, MA (2018–present)

Supervisors: Dr. Alex Latta, Dr. Andrew Spring (Laurier)

In response to the food security challenges in Canada's north, community gardens are being introduced into many communities to fill food access gaps. Three years after the establishment of a community garden in Kakisa, my research evaluated the impact using participatory action research methods to prioritize community members' needs and interests. It was an opportunity for community members to reflect on the impact of their garden, celebrate its successes, and identify barriers limiting production and participation. The community views the garden as a tool for self-sufficiency in their food system.

Participants noted the impacts of climate change on their traditional food sources, describing the garden as a useful adaptation. The community identified increasing the volume of food production as a priority, with capacity building as a critical factor. For Kakisa, this capacity building includes developing community members' knowledge of food production, preservation, and composting techniques. While similar community gardens have been initiated across the NWT, their impact and cultural relevance for Indigenous communities has not been well documented.

Taking care of the land through waste management

THE KAKISA WASTE MANAGEMENT INITIATIVE evolved out of Laurier's work to create a Climate Change Adaption and Food Security Plan for the community. In 2014-15 geography and environmental studies doctoral student Andrew Spring interviewed community members about changes they have witnessed to the land, how they were impacting community health and well-being, and what steps the community wanted to take to address these issues. Taking care of the land was a theme that emerged out of this work, and waste management and composting were identified as high priority issues. In 2015, a grant was obtained through GNWT in partnership with Ecology North and the Ka'a'gee Tu First Nation to start community consultation on how to design the program. In 2017, Master's student Michelle Malandra, alongside members of the community, worked to finalize the community plan and put it into action. She ordered infrastructure for the project and worked to engage and educate the youth. She went door-to-door in the community with a translator to speak with Elders and knowledge holders to ensure all members of the community were aware of the program. In 2018, the community built five waste sorting stations and installed a composter at the school. The program in Kakisa has resulted in approximately a 50% reduction in waste going to the dump.



Community Engagement with Ka'a'gee Tu First Nations

Neomi Jayaratne, MES (2018–present)

Supervisor: Dr. Andrew Spring (Laurier)

Communities in the NWT rely on the land as the basis of their food system and livelihoods. As climate change is having negative impacts on the lands, waters and animals, communities need to continually adapt to these changes. I am interested in creating space for youth and elder interactions on the land to promote intergenerational transfer of skills and traditional knowledge. I am also interested in using mapping technologies to share information and traditional knowledge of land conditions (past and present) to promote adaptation and harvester safety near Kakisa, NWT.

South Slave Projects – Biomonitoring



Understanding mercury influences in Tathlina and Kakisa Lakes

Ari Yamaguchi, MSc Candidate (2017–present)

Supervisors: Dr. Deborah MacLatchy (Laurier), Dr. Heidi Swanson (University of Waterloo)

The Ka'a'gee Tu First Nation (KTFN) heavily relies upon Tathlina and Kakisa lakes for commercial and subsistence uses. Past research has found that some of the commercially targeted fish in these lakes have more mercury in them than is considered safe by government guidelines. This study explores how mercury in the air and water ends up contaminating walleye, northern pike and lake whitefish in Tathlina and Kakisa Lakes.

Researchers and community members will collect samples of water, minnows, insects and soil from across the ecosystem's food web to find connections between environmental measurements and the amount of mercury in fish in these specific lakes. By predicting mercury exposure risks, we hope to provide decision makers with tools for public education on safe consumption practices and guidelines to reduce the health risks of mercury on community members.



Fish biomonitoring in Tathlina and Kakisa lakes

Andrea Lister, PhD Research Coordinator, (2010–present)

with Dr. Deborah MacLatchy (Laurier)

With concerns over the prospect of oil and gas development upstream in the watershed and the changing climate, our research initially focused on the implementation of baseline environmental monitoring studies of walleye and whitefish at Tathlina and Kakisa lakes in collaboration with Ka'a'gee Tu First Nation (KTFN) and researchers of the GNWT. In order to gain a better understanding of the resiliency of the fish populations, the research has expanded to involve studies of the lakes' ecology including the characterization of food webs and the transfer of mercury, as well as the development of an acoustic telemetry study of walleye that may identify over-wintering refuges and timing and locations of spawning. Tathlina Lake is a unique, shallow lake with low winter oxygen levels and historical documentations of fish stock declines. This work aims to inform the guidelines on safe levels of fish consumption based on mercury concentrations, increase our knowledge of the factors influencing the transfer of mercury in these aquatic environments, and gain insight into the sustainability of these culturally and commercially important fish species to the KTFN.



Fish ecology, contaminants, and moment across lakes in the Dehcho

Heather Dixon, PhD, GWF Research Associate (2017–present) with Dr. Deborah MacLatchy (Laurier)

I am investigating contaminant levels (particularly mercury) and trophic interactions in the food webs of subarctic lakes in the Dehcho region of the Northwest Territories, and developing an acoustic telemetry study to investigate walleye habitat use in Tathlina Lake. This work is important in developing updated consumption guidelines for mercury concentrations and for assessing the sustainability of fisheries in the Dehcho.

Dehcho and South Slave Projects - On-the-Land Education



Youth on the Land Camps

THE LAURIER PARTNERSHIP with Dehcho First Nations' Youth Ecology Camp helps engage youth in science and cultural traditions. Laurier researchers are growing indigenous youth connections to science and the land through a partnership with Dehcho First Nations to participate in the Regional Dehcho Youth Ecology Camp in 2018, which takes youth on the land to connect with Indigenous elders, traditional knowledge holders, scientists and each other. Twelve youth aged 11 to 16 from across the communities of Dehcho First Nations attended the camp at Willow Lake. While at the camp, Laurier researchers taught youth attendees about scientific techniques to measure changes in water quality, permafrost conditions and ecological function. The youth also learned from traditional knowledge holders, who provided Indigenous perspectives on the land and water.

Campers also learned about language from a language facilitator, about fish and aquatic sciences from Dehcho AAROM staff and about the Dehcho Land Use Plan from Dehcho land use planning staff and traditional knowledge holders.

Other partners in the Dehcho Youth Ecology Camp include Northwest Territories Municipal and Community Affairs, the Dehcho Land Use Planning Committee, Dehcho AAROM, Dehcho First Nations and the Deh Gáh Got'îê Dene Band, whose land the camp was held on. Partial funding for this program was received from NESRC Promoscience program.



Science Outreach and Youth Engagement

Stephanie Woodworth, PhD (2018–present)

Supervisors: Dr. Sonia Wesche (University of Ottawa), Dr. Andrew Spring (Laurier)

Innovative on-the-land camps are planned with community partners in the Northwest Territories (NWT) over the next three years to engage and empower Indigenous youth to be Guardians of their communities. The on-the-land education camps feature traditional activities led by elders and knowledge keepers, and hands-on science-based learning activities led by Northern Water Futures (NWF) researchers. My thesis project evaluates these on-the-land camps in the NWT in terms of the co-production of knowledge between science and Indigenous knowledges, whether the community goals are achieved, and how the camps engage and empower youth through traditional and scientific activities. Overall, I am exploring how the on-the-land education camps in the NWT empower youth to be future Guardians in their communities, as well as promote a common cross-cultural understanding of water knowledge and concepts of risk between community members and researchers. During the on-the-land camp experience, youth learn scientific inquiry, techniques and mapping technology to measure changes in water quality, permafrost conditions, and ecological function. The camps also include traditional knowledge holders who share Indigenous perspectives on the land and water. Together, science and traditional knowledge empower the youth through activities and games. This intensive, experiential format is preferred by communities in the North, as it fosters relationship building, mutual understanding and culturally appropriate forms of learning. As youth are important stakeholders in the North, opportunities to learn from both elders and researchers on the land will shape their abilities to be future leaders in their communities and inspire them to become involved in research and monitoring.

Sahtú Projects

Project	Research Location	Project Description	Contact
Our land is changing: climate change, food security and health in Délı̨nę	Délı̨nę	Assessing vulnerability of community members to climate change impacts with a focus on harvesting practices, adaptation strategies; Creating a community plan for climate change adaptation and country food security.	Andrew Spring
Climate warming impacts on runoff generation processes	Mile 222 Canol Trail	Studying how climate warming and direct human disturbance affects stream flows from high altitude basins.	Bill Quinton
Water knowledge camps	Délı̨nę Fort Good Hope Tulita	On-the-land camps to support sharing of traditional and western scientific knowledge about environmental change and development of monitoring tools for the Sahtú Guardians program.	Jennifer Baltzer Andrew Spring
Aquatic habitat inventory	Mackenzie River western bank across from Norman Wells.	Examining the diversity of zooplankton and benthic invertebrates in a region primed for future natural resource extraction.	Derek Gray
Sahtú Benígǫdi: Traditional knowledge of Great Bear Lake and its watershed	Délı̨nę	Cataloguing and collection of Traditional Knowledge regarding environmental and cultural aspects of the lake and its watershed, including knowledge related to fish, water, wildlife, and landscape change.	Gina Bayha (Tsá Tué Biosphere Reserve) (Laurier contact: Andrew Spring)



Climate warming impacts on runoff generation processes in an alpine basin, NWT

Geoffrey Kershaw, PhD Candidate (2016–present)

Supervisor: Dr. William Quinton (Laurier)

Alpine basins are known to have greater hydrologic variability across smaller areas due to changes in soil type, ecology, microclimate, and other site-specific factors. The role of ice-rich permafrost in alpine basins can accelerate runoff during the spring melt and early summer rain events, as well as impound surface water and cause hydrological isolation as the surface soils thaw in the summer. The goal is to characterize the hydrology of distinct landscape types present in alpine valleys and describe how they affect water storage and runoff dynamics throughout the year. My research will help individuals and policy makers prepare for this changing northern landscape. This work will also assist future remote sensing and hydrology modelling projects in the North, helping us predict the future conditions of our headwater systems and support water management decision making.

Inuvik Projects

Project	Research Location	Project Description	Contact
Hydrological implications of changes in climate, snow, vegetation, and permafrost (NWF)	Havikpak Creek, Trail Valley Creek, and sites along the Dempster and Inuvik to Tuk Highway (ITH).	Modelling interactions between climate, vegetation, snow, permafrost, and hydrology to understand impact of climate change on aquatic ecosystems and coastal environments.	Phil Marsh
How will fish communities in Gwich'in and Inuvialuit lakes respond to climate change?	Dempster Highway between Fort McPherson – Inuvik. ITH between Inuvik – Tuktoyaktuk	Developing models to predict future changes in fish species distributions under climate change scenarios along the NWT North-South transportation corridor.	Derek Gray Sapna Sharma
Impact of ferry landings on water quality and fish communities in the Peel and Mackenzie Rivers	Tsiigehtchic and Fort McPherson	Combining limnology and traditional knowledge to examine how the annual construction of ferry landings impacts water quality and fishing.	Derek Gray Alex Latta
Impacts of permafrost thaw on invertebrate communities in Gwich'in and Inuvialuit Lakes	Dempster Hwy between Inuvik -Fort McPherson. ITH between Inuvik - Tuktoyaktuk	Examining invertebrate communities in lakes impacted by retrogressive thaw slumping versus those without obvious permafrost degradation.	Derek Gray
Permafrost terrain sensitivity	ITH	Evaluating the accuracy of RADARSAT-2 DInSAR products using fine-scale geomorphological maps and field-based studies, along with additional remote sensing tools.	Ashley Rudy
Understanding the impact of shrub expansion on the tundra	Trail Valley Creek	Characterization of the impact of tall shrub patches on soil, snow, and permafrost conditions and the resulting impacts on tundra biodiversity.	Jennifer Baltzer
Climate change vulnerability	Tuktut Nogait National Park	An assessment of how climate change is affecting, and predicted to influence, ecological changes and the implications for park management, ecological integrity, and traditional lifestyles.	Christopher Lemieux



Fine-scale geomorphological mapping and field based studies along the Inuvik to Tuktoyaktuk Highway corridor

Ashley Rudy, PhD (2017–18) GWF Research Associate, Permafrost

Supervisor: Dr. Philip Marsh

I am studying the accuracy of RADARSAT-2 products using fine-scale geomorphological maps and field-based studies to explore permafrost terrain sensitivity along the Inuvik to Tuktoyaktuk Highway corridor. The work will provide new insights on the rate and nature of change, and will be valuable as a long-term monitoring tool to track surface displacement related to seasonal thaw and permafrost degradation. The resulting displacement maps will provide a tool for monitoring long-term terrain stability, evaluating infrastructure performance, and informing regional climate-change adaptation strategies. We are also combining an extensive collection of existing field data with ERT profiles of different forms and stages of permafrost degradation to examine broader landscape controls. This is a unique opportunity to provide subsurface information on the state of permafrost in this discontinuous permafrost zone providing insight into landscape controls on permafrost degradation.

Inuvik Projects



Factors influencing zooplankton community structure in small Arctic lakes

Jasmina Vucic, MSc (2017–present)

Supervisor: Dr. Derek Gray (Laurier)

Climate change may alter lake water levels through changes in ice coverage, water flow, net basin water supplies, and evaporation. This research is examining how climate change impacts zooplankton communities in 56 lakes along the Dempster Highway and the Inuvik-Tuktoyaktuk Highway running from Fort McPherson to Tuktoyaktuk. This research will contribute to understanding the fundamental processes that structure zooplankton communities in Gwich'in Settlement Area (GSA) and Inuvialuit Settlement Region (ISR) lakes. Furthermore, the data collected from this project will be used in an ongoing project that is assessing the impacts of climate change on important food and sport fish species in the Northwest Territories.



Factors associated with macroinvertebrate communities in Canadian Arctic lakes

Rachel Cohen, MSc (2017–present)

Supervisor: Dr. Derek Gray (Laurier)

Freshwater lakes are experiencing changes in water levels, water temperatures and nutrient concentrations as a result of climate change. This study investigates the factors that influence macroinvertebrate community composition in 46 small to medium-sized lakes along the (Dempster and Inuvik-Tuktoyaktuk) highways that run between Fort McPherson, Inuvik, and Tuktoyaktuk. Biological (macroinvertebrates, fish), morphometric (surface area, maximum and mean depth) and water quality (turbidity, Secchi depth, pH, conductivity, dissolved oxygen, lake temperature, chlorophyll-a, nutrient and chemical concentrations) data were collected. With this data, the study will investigate which environmental variables impact macroinvertebrate communities in Gwich'in Settlement Area (GSA) and Inuvialuit Settlement Region (ISR) lakes to predict how lake ecosystems may respond to changes in climate and development in the GSA and ISR.



Impacts of ferry landings in the Gwich'in Settlement Area

Matthew Teillet, MSc (2017–present)

Supervisors: Dr. Derek Gray (Biology), Dr. Alex Latta (Global Studies, Laurier)

Gwich'in communities have fished around the ferry landings for centuries and rely on fish for their livelihood. This study explores whether sediments from the landings are eroding downstream, which may change the shape and depth of the river, altering traditional fishing areas, and could affect fish populations. To determine the impacts of ferry landings in the Gwich'in Settlement Area on water quality and fishing opportunities, water and sediments are being sampled upstream and downstream of the ferry landings on the Peel and Mackenzie Rivers. Meetings and interviews held in each community will collect traditional knowledge about noticeable downstream impacts over the history of the ferry landings. Results will be presented in each community to collectively derive conclusions.

Impacts of tall shrub expansion on tundra ecosystem function

THE EXPANSION OF THE number and size of tall shrubs on the tundra ecosystem affects where animals live, the availability of food for prey animals and the amount of water available to move across the landscape. The ability to predict change during this expansion is imperative to understanding how the land is changing.



Drivers and consequences of alder expansion at the treeline-tundra ecotone

Cory Wallace, PhD Student (2014–present)

Supervisor: Dr. Jennifer Baltzer (Laurier)

Warming temperatures have resulted in a large increase in the size and abundance of shrubby vegetation in the Arctic tundra over the past few decades. At Trail Valley Creek Research Station, we found that alder patches did have different soil conditions, particularly differences in nutrient availability, greater snow depth, and drier soils as well as greater cover of evergreen shrubs and fewer species specialized to tundra conditions. This data also allowed us to test whether any of these conditions were influenced by the physical characteristics (e.g. density and average height) of individual patches. We are investigating where across the landscape green alder seedlings will establish by mapping the locations of individual seedlings and comparing this to local environmental conditions and seed density. This work will give us both a better understanding of the environmental impacts of green alder shrub expansion in the tundra of the Northwest Territories and a sense of where to expect future expansion to occur. These two pieces of information will help refine the picture of what a future, more shrubby tundra will look like and the impact this may have on wildlife habitat, local water resource availability, and regional climate change.

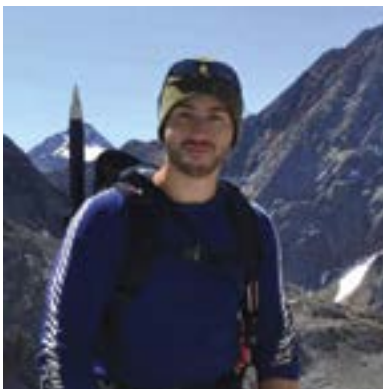


Water use by tall shrubs in tundra environments

Katie Black, MSc (2015–17)

Supervisor: Dr. Jennifer Baltzer (Laurier)

Climate warming is driving the expansion of shrubs across the tundra, especially in areas that have a higher potential of accumulating moisture, such as hill slopes and drainage channels. We offer estimates of seasonal variation in green alder daily cumulative sap volume and green alder patch transpiration on the low Arctic tundra, supporting incorporation of shrub water use estimates into models predicting the magnitude and impacts of tundra shrubbing on evapotranspiration. Green alder is expanding rapidly across the low Arctic tundra of the Northwest Territories and understanding the implications of its expansion is essential for predicting future tundra conditions.



Instrumentation support across multiple sites

Gabriel Hould Gosselin, Biogeochemistry Research Associate (MSc Blng)

working with Dr. Philip Marsh (Laurier), Dr. Oliver Sonnentag (Université de Montréal), Dr. Jennifer Baltzer (Laurier), Dr. William Quinton (Laurier)

The primary focus of my work is to design, install and maintain eddy covariance and micrometeorological instrumentation, as well as to support other CANet activities at six sites on a latitudinal gradient across the NWT and northern BC. I specialize in establishing water vapour, carbon dioxide and methane fluxes at a landscape scale using the eddy covariance technique. These datasets are imperative to provide better process-based understanding of how boreal forest, peatland and tundra ecosystems under the influence of rapidly changing permafrost conditions function as an integral part of the climate system.

Impacts of tall shrub expansion (continued)



Spatial and temporal variability of the snow environment in the Western Canadian Arctic

Philip Mann, MSc (2014–17)

Supervisor: Dr. Philip Marsh (Laurier)

My research quantifies spatial variations in end-of-winter snow cover by using a variety of new techniques in Trail Valley Creek. Snow cover in the Western Canadian Arctic is a significant input to the hydrological mass balance, it produces shelter and habitat for animals and humans, and supports interactions with vegetation and climate. It is also greatly impacted by wind erosion, redistribution and deposition of snow during high wind events over the winter months. As a result, the end-of-winter snow cover is characterized by significant small-scale spatial variations in snow depth, density, snow water equivalent and runoff. Therefore, as the climate and vegetation continue to change in the coming decades, it is expected that there will be great changes in snow cover and, consequently, impacts on water resources, animal habitats and vegetation.



High-resolution spatial variability in spring snowmelt for an Arctic shrub-tundra watershed

Branden Walker, MSc (2015–18)

Supervisor: Dr. Phillip Marsh (Laurier); Research Associate (2018-present)

My research is aimed at understanding how Arctic hydrological systems are responding to a rapidly warming climate. As a previous master's student, my research applied novel techniques such as unmanned aerial systems (UAS) to map snowpack conditions across shrub-tundra headwater catchments. This research addresses uncertainties relating to future changes in snow distribution with increasing shrub expansion into tundra regions and changing precipitation regimes. My work also aims to increase our knowledge of the complex and rapid changes to basin snow cover conditions over the spring melt to improve our understanding of the spring freshet response which is integral to improving our ability to forecast these systems under further climate warming scenarios. Alongside my ongoing research interests, I am also responsible for the management and operations of the Trail Valley Creek Research Station.

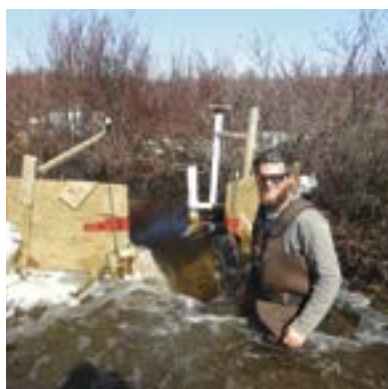




THE TRAIL VALLEY CREEK (TVC) RESEARCH STATION is located 50 km north of Inuvik, Northwest Territories. Environment Canada began streamflow measurements here in 1979, and hydrological research in 1991. Laurier has carried out research here since 2013 and currently operates a 15 person research camp. This camp is available for use year round.

The Trail Valley Creek watershed is 58 km² area, and is characterized by tundra, with patches of shrubs and forest, and ice-rich continuous permafrost. This area is one of the most rapidly warming regions on Earth, with decreasing precipitation, thawing of permafrost, expansion of shrubs, thinner snow covers that are melting earlier in the spring, but few changes in runoff.

Currently research at TVC is focused on integrating our understanding of the links between climate, vegetation, snow, and permafrost, and the controls on streamflow and lakes. This research, and the datasets being developed, contribute to a deeper understanding of the effects of warming in this geographic region, and the development of a new generation of predictive models.



Assessing the hydrological variability of thermokarst lakes

Evan Wilcox, PhD (2017–present)

Supervisors: Dr. Philip Marsh and Dr. Brent Wolfe (Laurier)

The thermokarst lakes between Inuvik and Tuktoyaktuk are vulnerable to changing water levels as the climate warms. I am looking at the lake and landscape properties that control changes in lake water levels to determine the relative importance of snowmelt and rainfall for recharging lakes near the Trail Valley Creek Research Station. I have collected water samples from more than 120 lakes across a 2,000 km² area, which will be analyzed for multiple hydrological indicators, including snowmelt and rainfall recharge. These indicators will then be compared to multiple lake and catchment characteristics, such as the lake area-catchment area ratio, to determine the influence of such landscape elements on lake water levels. From this work, the general hydrological behaviour of lakes will be more easily estimated based on easily quantifiable lake and catchment characteristics. This is relevant for future industrial development in the area and for predicting future changes to lake water levels as the climate warms.



Hydrothermal regime of stream channels on Tuktoyaktuk coastlands and Anderson plain

Timothy Ensom, PhD Candidate (2017–present)

Supervisors: Dr. Philip Marsh (Laurier), Dr. Steve Kokelj (NWT Geological Survey)

This research will improve understanding of temperature and flow in small stream channels in continuous permafrost on the Tuktoyaktuk Coastlands and Anderson Plain, NWT, and to explore the implications of a changing climate. We hypothesize that insulation from snow cover in combination with adequate watershed storage capacity can permit flow to continue through winter in small stream channels. To test this hypothesis, we are monitoring water and ground temperature in, beneath and adjacent to streams of varying catchment size across the treeline. We are also comparing the morphology and vegetation of contributing watersheds and describing the hydrological activity, thermal conditions, and the distribution, timing and magnitude of stream icings indicative of winter water movement for streams intersected by the 130-km Inuvik to Tuktoyaktuk Highway (ITH). This research has the potential to provide new insight on winter hydrology in permafrost areas. The results are expected to inform the design, operation and mitigation of hydrological issues associated with linear infrastructure in permafrost.

Trail Valley Creek Research Station



Changes in lakes along the Inuvik-Tuktoyaktuk Highway (1950-2011)

Dilshan Kariyawasam, MSc (2018–present)

Supervisor: Dr. Philip Marsh (Laurier)

The ITH traverses a region of continuous permafrost, and the number of lakes increases as you travel further north along the highway. Understanding what lakes looked like in the past and comparing it to how they currently appear can give a better understanding of the changes occurring in the area. Using mapping software, it will be possible to quantify the number of lakes on the landscape, as well as how much each lake has changed over time (area and perimeter). We will share findings with the community via interactive workshops held at East 3 High School and deliver presentations at Aurora Research Institute. Collaborating with communities and exchanging our observations, we will be able to determine how lakes along the ITH are changing. This work is critical in understanding to provide specific areas for further work. These lakes are a source of water, cultural importance, habitat for wildlife, and play an important role in the ecosystem's functionality.



Projects Across Other Northern Regions

Project	Research Location	Project Description	Contact
Transboundary			
Discerning effects of multiple stressors (climate change, river regulation, oil sands development) on lakes	Peace-Athabasca Delta	Application of contemporary and paleoenvironmental approaches to identify cause and effect and to inform water resource management.	Brent Wolfe Roland Hall
Impact of large-scale wildfires in boreal watersheds with oil sands development	Lower Athabasca River, Alberta	Understanding how wildfire alters ecological integrity within the Athabasca river and tributary streams in northern Alberta.	Joseph Culp Jordan Musetta-Lambert
High Arctic			
Arctic freshwater watersheds: validating protocols for monitoring and cumulative impacts assessment	Cambridge Bay, Canadian High Arctic Research Station, Nunavut	Understanding the role of lake and river food webs as sources and sinks for nutrients and carbon.	Joseph Culp

Peace-Athabasca Delta (PAD) Research Projects

THE PEACE-ATHABASCA DELTA (PAD) has been central to the lives of the first nations communities of fort chipewyan for centuries. It is the world's largest boreal freshwater delta. For the past 50 years, there have been many unresolved concerns over the potential effects of major energy projects, climate change and reduced river discharge on lakes in this floodplain landscape.



Identifying main influences on lake carbon balance in the Peace-Athabasca Delta

Laura Neary, MSc (2018–present)

Supervisors: Dr. Roland Hall (University of Waterloo), Dr. Brent Wolfe (Laurier)

Examining hydrological and limnological variables can further identify factors that control lake carbon balances across the Peace- Athabasca Delta and major influences on lake carbon balance at 62 lakes and nine river sites in the PAD. Improved understanding of influential processes affecting carbon balance in northern floodplain lakes will allow decision makers to accurately quantify their importance to global carbon budgets and to forecast responses to anticipated climate change.

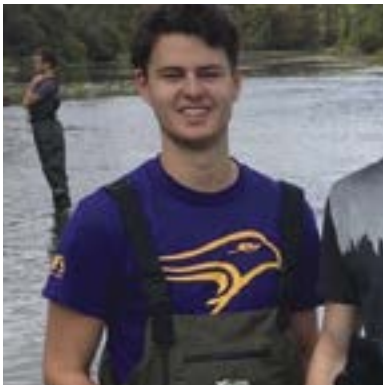


Discerning the effects of multiple stressors on lakes in the Peace-Athabasca Delta

Mitchell Kay, PhD Student (2017–present)

Supervisors: Dr. Roland Hall (University of Waterloo), Dr. Brent Wolfe (Laurier)

We are applying paleolimnological approaches at 15 strategically selected lakes in the Athabasca Delta. This will provide critically missing long-term information on pre-industrial baseline levels of metal contaminants carried by the Athabasca River as well as identifying the key hydroecological drivers that are causing the perceived declines in river flow and flood frequency at the eastern terminus region of the Athabasca Delta. These findings are important for decision makers tasked with determining if the status of this UNESCO World Heritage Site should be changed to 'World Heritage in Danger' and formulating an action plan to protect the hydroecological integrity of the delta's perched lakes.



Paleolimnological reconstruction of past hydrologic conditions at Egg Lake in the Peace-Athabasca Delta

Colin Burchill, BA (2016–19)

Supervisors: Dr. Brent Wolfe (Laurier), Dr. Roland Hall (University of Waterloo)

Examining the past hydrological and climatic conditions of Egg Lake, a lake that has been frequented by the local First Nations for many years will provide insight on hydrological conditions in the Peace-Athabasca Delta. Several sediment cores have been extracted from the lake as they provide a long time scale to compare the past and the present. Many lakes that have been studied in the past were chosen for scientific reasons and may not reside in areas frequently accessed by local First Nations. A lake of local significance was chosen to perform this analysis so that it would resonate more with decision makers in the area and hopefully lead to effective management strategies and the preservation of the PAD.

Other Northern Regions: Transboundary and High Arctic



Impact of large-scale wildfires in boreal watersheds with oil sands development

Jordan Musetta-Lambert, PhD Postdoctoral researcher (2018–present)

with Dr. Joseph Culp (Laurier)

Wildfires are dominant natural disturbances in the boreal and will increasingly occur due to climate-driven intensification of droughts. Aquatic ecosystems are highly interconnected to adjacent terrestrial landscapes and, therefore, are sensitive to disturbances such as wildfire. My research focusses on understanding how wildfire alters ecological integrity within the Athabasca river and tributary streams in northern Alberta where the Horse River fire burned ~590,000 hectares in 2016. Due to oil sands development in this region, water quality, habitat and aquatic macroinvertebrate data has been collected since 2011. This data provides the unique opportunity to investigate the effects of wildfire on aquatic ecosystems using a before-after-control-impact design and to separate the effects of oil sands development from the confounding effects of wildfire to aid effective watershed management.



Prey selectability exhibited by ninespine stickleback in Arctic streams of the Greiner Lake watershed

Adam Kuhrt, MSc (2018–present)

Supervisor: Dr. Joseph Culp (Laurier)

My project aims to determine prey selectability exhibited by ninespine stickleback on benthic macroinvertebrates in Arctic streams of the Greiner Lake watershed in Nunavut. The methods I will use are CABIN protocol kick-nets at study sites to determine aquatic invertebrate community structure, as well as gut content and stable isotope analyses to determine prey selection. Statistics will be used to explore the significance of prey selectability carried out from a taxonomic and traits- based perspective. The research proposed here is part of a multi-thematic study with the aim of developing a multi-trophic understanding of food webs in the Greiner Lake watershed.



Runoff characteristics of fen peatlands across a north-south transect in the Hudson Bay Lowlands

Mikhail Mack, PhD Student (2017–present)

Supervisors: Dr. William Quinton (Laurier), Dr. James McLaughlin (Ontario Ministry of Natural Resources and Forestry)

In peatland-dominated watersheds, fens often connect drier landforms, such as bogs, peat plateaus, and palsas, to incised drainage networks that carry water to the watershed outlet. The main objective of my research is to gain a better understanding of fen peatland hydrologic behaviour in the Hudson Bay Lowlands (Ontario, Canada) by describing their distribution along a north-south transect and quantifying the volume and timing of their runoff at two fen sites with contrasting surface water storage characteristics. The Hudson Bay Lowlands (HBL) ecoregion of central Canada is the world's third-largest contiguous wetland complex (325,000 km²) of which 85% is classified as peatlands or mineral wetlands. Improved hydrologic models can be developed for the HBL by increasing our understanding of fen runoff characteristics. The provincial government and First Nation communities from this area are keen to understand the impact climate change will have on the water resources of the HBL.

Development and Tourism

ENVIRONMENTAL PLANNING research informs the management of human activities on the land and management of resources to preserve ecological integrity and ensure sustainability. The development of hazard maps for risks and vulnerabilities, and studies on the impacts of tourism play critical roles in underpinning effective planning approaches throughout the NWT.



Understanding motor vehicle-based travel: Examining the experiences and perceptions of Yukon tourists

Natalia Wegrzyn, MES (2014–present)

Supervisor: Dr. Scott Slocombe (Laurier)

This study used an exploratory approach to understand the relationship between northern tourism, drive tourism and the tourist experience through a case study in the Yukon. Motor vehicle-based tourists' narratives were used not only to explore choices and behaviours but to also understand the potentially far-reaching implications on the Yukon's destination image when tourists share their experiences with others.

Based on the research results, this study makes suggestions for the Yukon Visitor Tracking Program survey to include questions that ask tourists to reflect on their experiences during travel. This study suggests that offering survey users the opportunity to provide a personalized account of their experiences will give tourist managers insights into how the tourism market may unfold beyond the reach of their marketing strategies.



Policy, plans and processes for the development and use of hazard mapping in climate change adaptation planning

Stephanie Pike, MES (2016–present)

Supervisor: Dr. Scott Slocombe (Laurier)

As changes in climate continue, natural hazards such as floods, droughts and permafrost thaw are becoming a greater concern for communities in Canada's North.

Improving hazard mapping in Yukon communities can provide residents with more information on potential risks and changes and in turn allow for early adaptation and preparation. The purpose of this research is to identify and assess policies, plans and processes currently in place in the Yukon for reducing impacts of hazards in Yukon communities and the adjacent wildlife and ecosystems they depend on. This project is geographically focused on the neighbouring communities of Burwash Landing and Destruction Bay, as well as on Old Crow.

This work is relevant for both the developers of hazard mapping tools and the users. The main goal of this research is to connect hazard mapping research to community needs, and opportunities for adaptation and mitigation to assist with both development and adaptation to future changes to the land and ecosystems.



Mining and Risk Assessment

ENVIRONMENTAL PLANNING research informs the management of human activities on the land and management of resources to preserve ecological integrity and ensure sustainability. The development of hazard maps for risks and vulnerabilities, and studies on the impacts of tourism play critical roles in underpinning effective planning approaches throughout the NWT.



Development of geochemical parameters to assist with risk assessment for mining of rare earth elements

Weibin (Ben) Chen, Postdoctoral researcher (2017–present) with Dr. Scott Smith and Dr. James McGeer (Laurier)

Rare earth elements (REEs) are considered “data poor” when it comes to understanding their geochemistry in surface waters and the links between this chemistry and their potential toxicity. The least understood aspect of REEs is their complexation by dissolved organic matter; which can mitigate their toxicity and quantifying this binding is necessary to properly assess risk in receiving waters, such as in the NWT. The current state of the art in metal-organic matter complexation predictions is the Windermere Humic Aqueous Model (WHAM). To run this model, binding constants must be determined. Our project involves measuring these values for diverse organic matter sources and comparing them to default WHAM values. We have found that WHAM parameters overestimate binding by many orders of magnitude at low REE concentrations. Our work will refine WHAM so it can be appropriately used for risk assessment of potential future REE mining operations.



Development of solubility models for rare earth elements for use in the aqueous environmental risk assessment of rare earth elements

Seana Brennan, MSc (2016–present)

Supervisors: Dr. Scott Smith and Dr. James McGeer (Laurier)

REE occur in water as trivalent cations, and they are often of low solubility in surface waters. This low solubility makes performing toxicity assays very difficult, both in terms of doing the actual test and also in interpreting the resultant data. These toxicity assays are essential to establish safe limits of REE in surface waters. Geochemical tools exist to predict solubility of elements for given water chemistry but the parameter values (Ksp values) that determine solubility of rare earth elements are uncertain by two orders of magnitude in standard databases. My research involves detailed and systematic variation of water chemistry parameters and measuring the impact on REE solubility. The result will be improved precision and accuracy on Ksp values for REEs and ultimately result in improved predictions of REE impacts in surface waters of the NWT.



The importance of dissolved organic matter in mitigating the impacts of legacy contaminants in northern aquatic ecosystems

Leah Mindorff, BSc Honours (2018–present)

Supervisors: Dr. James McGeer and Dr. Scott Smith (Laurier)

Dissolved organic matter (DOM) can bind metals and reduce their bioavailability and toxicity. This is relevant to areas in the NWT that have experienced metal contamination from mining activities. While DOM quantity is known to influence toxicity, less is known about the role DOM quality plays. To better understand the unique qualities of northern DOMs, I am studying samples collected from lakes around Yellowknife. My goal is to identify the chemical components and the metal binding characteristics of these samples. Understanding the relationships between chemical makeup and metal binding affinity will support the incorporation of DOM quality into toxicity prediction models. This work will contribute to improved environmental impact assessment in northern ecosystems and provide managers with relevant models that account for site-specific differences.



Centre for Cold Regions and Water Science Based Projects

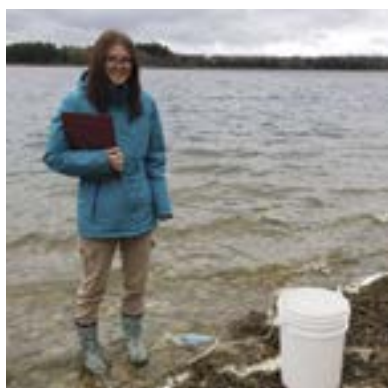
Architect: Parkin Architects Limited

The 1418 square metre Centre for Cold Regions and Water Science (CCRWS) is a 2014 American School and University outstanding design award winner and home to research facilities that meet green environmental standards. A working lab, CCRWS blends light filled spaces with facilities that replicate arctic climate conditions. It is a collaborative research facility that houses four research centres/groups and a variety of state-of-the-art analytical equipment. The facility, which opened in 2013, is funded by Laurier, the Government of the Northwest Territories, the Canada Foundation for Innovation (CFI), the Ontario Ministry of Research and Innovation (MRI), and the Federal Economic Development Agency for Southern Ontario (FedDev Ontario).



Project	Research Location	Project Description	Contact
Laboratory Modelling			
Interactions of dissolved organic matter, toxicity of metals, nutrients and rare earth elements	Laboratory studies	Examining the relative sensitivities of northern and southern fish species to the toxic effects of metals and rare earth elements.	James McGeer Scott Smith

Centre for Cold Regions and Water Science Based Projects



Testing remote sensing methods to determine dissolved organic carbon for metals risk assessment in surface waters

Mickey Nielsen, BSc (2015–18), MSc (starting January 2019)

Supervisor: Dr. Scott Smith (Laurier)

It is well established that specific water chemistry of a lake can influence the toxic effects of metals; in particular, the presence of dissolved organic matter (DOM) can decrease the toxicity of copper, nickel, lead and zinc. This effect can quantitatively be predicted using established biotic ligand models (BLMs). Many governments recommend use of BLM approaches for establishing site-specific water quality criteria or for risk assessment, but many lack the ability to consistently and accurately measure dissolved organic carbon (DOC). It may be possible to use remote sensing to measure the colour associated with dissolved organic matter (CDOM) if we can convert measurements of CDOM to a prediction of DOC in freshwater environments. We are studying remote, unimpacted lakes using both drone- and satellite-based remote sensing methods to compare estimated CDOM to metals risk estimates and to actual measured effect concentrations in samples of these same site waters. The comparison will allow us to assess the feasibility and practicality of remote sensing as a tool for metals, including copper, zinc, lead and nickel, risk assessment for current and future mineral extraction or waste disposal activities in the NWT and other cold regions.



For more information about any of these projects or to participate in our initiatives, please visit our offices in Yellowknife and speak with our researchers.

Laurier Yellowknife Research Office
5007- 50th Avenue
Yellowknife, NT X1A 2P8
E YKOffice@wlu.ca
T 867.688.2605

wlu.ca/northern-research



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