December 2022 Issue 3

TRIA-FoR: Transformative Risk Assessment and Forest Resilience Using Genomic Tools for the Mountain Pine Beetle Outbreak

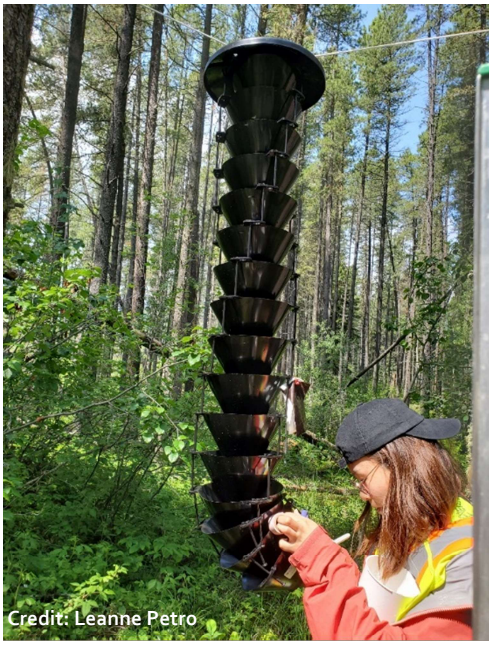
Newsletter

Credit: Antonia Musso


Credit: Rhiannon Peery

In This Newsletter

What's New?


Credit: Leanne Petro

University of Alberta MSc student Yiyang Wu (Evenden Lab) labelling an MPB funnel trap.

TRIA-FoR has completed its first 12 months of operations, and the team has carried out the first summer field season of the project. In this section, our aim is to provide a brief update on project progress, with a focus on the specific research activities.

All TRIA-FoR research activities rely on complex field work for sample collection over the course of the project. Our **Activity 1 - Coordinated field activities** include pine and mountain pine beetle (MPB) sampling, as well as field data that are collected and processed across numerous sites. Field activities and collections are also coordinated in close collaboration with several of our partner organizations and collaborators. Over the last six months the University of Alberta students and staff really stepped up to make the MPB field collection a success despite facing

numerous challenges including reduced prevalence of MPB over this year due to effective Province of Alberta control methods, as well as the environmental conditions during the summer. However, our team proved resilient, and using MPB baiting and trapping approaches, identified sufficient MPB mass-attacked trees and sites. for upcoming beetle experiments. In terms of tree collections, sampling of georeferenced pines through the lodgepole x jack pine zone of introgression was carried out, following a transect transitioning from pure lodgepole pine in western Alberta to pure jack pine, and materials prepared for DNA extractions. Collaborative work is ongoing with Dr. Michael Lipsett's team (Mechanical Engineering, University of Alberta) on a drone autosampler with imaging camera capable of sampling branches from the upper canopy in natural stands. This will facilitate tree sampling in the future.

An MPB larva (asterisk) revealed following removal of the tree bark. To provide a size reference (insert), a larva is shown in the palm of a hand.

In our effort to characterize **Activity 2 - Lodgepole pine genetic resilience to MPB,** population and quantitative genomics is being used to identify and validate genetic loci that predict MPB resiliency in lodgepole pine, and to identify traits and genes that contribute to MPB resiliency. We're also modelling the impact of planting MPB-resilient lodgepole pine on outbreaking MPB populations. Seedlings representing 16 full-sib and 100 half-sib lodgepole pine families with contrasting MPB resilience vs susceptibility have been grown by our partners at BC FIRM (British Columbia Forest Improvement and Research Management Branch) staff with delivery to the Cooke lab at University of Alberta expected during February. These seedlings will be used as source material for genomic selection validation analyses, and a comparison of the responses of MPB resilient/susceptible lodgepole pine seedlings to wounding and *Grossmania clavigera* (a pathogenic fungal symbiont transmitted by MPB) inoculation. Regarding the modelling of MPB outbreak potential under different scenarios of lodgepole pine resiliency, results to date model transient outbreaks of MPB in age structured forests and allows for endemic beetle populations to survive by attacking trees with low

resilience. Efforts are underway to incorporate environmental covariates with the MPB data acquired from the Alberta Ministry of Forests, Parks and Tourism.

Carleton University MSc student Jess Duffy (Cullingham Lab) harvests pine seedlings grown from seed from different locations, for DNA extractions and sequencing.

Our **Activity 3 - MPB eastern spread risk: Effect of pine host** will use landscape genomics to test whether pure jack pine can support MPB populations, or whether populations are sustained by the lodgepole x jack pine hybrid zone. In addition, an MPB eastern spread risk model will be developed incorporating the spatial genetic structure of jack pine. Prior to modelling eastern spread risk based on genetic ancestry of stands, we are working to further refine our original predictive map of lodgepole pine, jack pine, and lodgepole x jack pine hybrid distributions. We developed a new model, using ordinal regression that explicitly models the hybrid category. This second model has resulted in an over-estimation of the hybrid category, and when each model was tested using an independent data set of > 1,000 samples, the errors for the original model were much lower than for the new model. We are currently processing various seedlots from within and near the hybrid zone in Alberta to be used for genotyping and model refinement. As we work to characterize the genic and transcribed regions of jack pine associated with responses to MPB attack, several jack pine transcriptomes have been assembled, and significant progress was made identifying conserved regions for exome (the protein coding region of the genome) capture probe design. This same approach was also used successfully on lodgepole, red, and white pine, to allow cross species comparisons. Over 200 jack pine samples have been prepared from our extensive sample collection for DNA extraction and future analysis. Finally, as we move towards developing a model of eastern spread risk, the models under development in Activity 2 will be able to provide insight here. These models incorporate beetle spatial dynamics and available data on the natural resilience of trees. Most recently, we created a database which contains data on MPB infestations in Alberta over the last 20 years, beetle management and control information during this time period, as well as associated environmental covariates that affect MPB dynamics, for use in model refinement. Our models for predicting levels of MPB infestation are currently being assessed for their fit with the data, and their capacity to predict future MPB infestation levels.

Complementing our study of the pine host, **Activity 4 - MPB eastern spread risk: Beetle physiology and behaviour as drivers of spread** efforts will facilitate our understanding

of factors affecting MPB physiology and behaviour, and any subsequent impact on beetle spread and outbreak potential. We are targeting how overwintering temperatures and pine host attributes in these marginal habitats affect MPB fitness, as well as the analysis of MPB populations for genomic signatures of adaptation to these novel habitats. We will also integrate MPB host-influenced trait information into development of the MPB eastern spread risk model. Bolts from trees baited for beetle collection (referenced in Activity 1) are being sampled across time points throughout the winter. This began in October, with additional sampling planned for January and April 2023. These samples will be used to generate data on MPB overwintering physiology and chemical ecology, including body composition, beetle survival, ion balance in MPB hemolymph following cold stress, and respirometry. As we move to identify signatures of local adaptation of expanding MPB populations, 64 genomes representing three *Dendroctonus* species have been sequenced and are under analysis. In addition, potential genetic variation associated with cold tolerance in MPB through comparison of samples from Arizona and Hinton, AB is under assessment. To identify factors that influence MPB adult flight and host colonization traits through an impact on energetic state, preliminary trials have tested the trade-off between MPB flight, energy expenditure and metabolic rate. In addition to lab trials, funnel trap field sampling in five sites across the expanded range in Alberta was conducted throughout the 2022 flight season. Samples are being processed to determine the body condition of beetles across this expanded range.

Bolts cut from MPB-attacked trees in Alberta are sealed with paraffin to prevent dehydration, and can be sent to the Ontario research team, providing live MPB for experimental use.

On the societal, economic and policy front, **Activity 5 (GE³LS) - A framework of anticipating risks, trade-offs and fostering resilience related to MPB outbreaks and adoption of genomic-enhanced tools for risk management planning** will assess geographic, sociological, economic and policy aspects of risk related to the MPB epidemic and identify factors that influence stakeholder willingness to adopt genomics-informed applications. In addition, we will examine processes of communication and knowledge exchange, multi-jurisdictional risk management coordination, and economic cost-benefits and trade-offs associated with MPB outbreaks. Knowledge exchange plays an important role in how MPB risk is perceived and ultimately managed. To understand this, interviews with MPB experts were

carried out, revealing that MPB knowledge exchange is highly centralized, with government ministries/agencies making up most of this exchange, most often involving the sharing of MPB survey data and advice to other ministries, and provincial forest ministries. To further understand the factors affecting how MPB risks are perceived and communicated, a study of risk communication in news media coverage of MPB outbreaks revealed that communication about the social and ecological risks of MPB outbreaks varied across geographical contexts. As the impact of, and response to MPB is multi-jurisdictional, the assessment of challenges and solutions of multi-jurisdictional MPB risk management coordination revealed that MPB policy and governance responses of different provinces and federally demonstrated that these jurisdictions have evolved through distinct MPB response phases. These provinces don't just repeat the same response pattern but are learning and building upon the experiences and innovations of previous provinces.

In an effort to characterize costs and benefits, social preferences, and trade-offs to understand willingness of various stakeholders and communities to adopt new practices or technologies for managing MPB, the GE^{3}LS team has scheduled Stakeholder Preference Workshops and additional community engagement in BC and AB for January 2023. From their efforts to date, they've learned that based on community characteristics and each community's experiences with MPB, each community has a different history with, and relation to, MPB. An additional current focus is on the recreational value of parks, and what threat MPB poses for national and provincial parks. An elaboration of this will clarify the potential losses associated with MPB outbreaks in parks, compensation, and potential willingness of public users to pay for more intensive MPB management approaches.


Credit: Valerie Berseth

Carleton University PhD student Jenna Hutchen (Nguyen Lab) studies MPB spread and management activities in northern Alberta during a fieldwork visit.

TRIA-FoR project oversight is covered under **Activity 6 - Project Management**, which involves two Project Managers (PMs), one based at the University of Alberta and the other at Carleton University. In addition to budget tracking and financial reporting aspects, PMs contribute to project communications, and data management. To date, we have developed a robust internal team communications network involving the TRIA-FoR Slack channel, as well as by using Carleton University's Citrix ShareFile document sharing portal, in which all project-associated materials are maintained there and accessible by team members. We are currently developing a monthly Zoom-based seminar series for project participants, launching in January 2023. This will allow project students and post-docs to interact with each other routinely. Regarding external project

communications, the TRIA-FoR website is currently under development at the University of Alberta, and we continue to publish the TRIA-FoR newsletter bi-annually, coordinated with our research reporting efforts, as well as maintain a social media presence via a Twitter account. To facilitate knowledge translation into deliverables, we will be engaging our Stakeholder and End-User Committee (SEAC), and plan on scheduling the first meeting during early 2023. Finally, as TRIA-FoR begins to generate and accumulate data, robust data management will be of prime concern, and a Data Management Plan (DMP) is under development.

New Team Member Introduction

Dr. Colleen Fortier (Project Manager – University of Alberta):


Credit: Colleen Fortier

I was born and raised in St. Albert, a city just outside of Edmonton. I started my BSc at the University of Alberta in 2009, initially minoring in Art and Design and then History, before finishing with a double major in Biology and Chemistry. Considering my black thumb, I had never anticipated working with plants to be in my future, taking my first Botany course merely to satisfy graduation requirements. However, I quickly realized how complex and fascinating plants are, particularly their diverse biochemistries. I was recruited to the Cooke Lab by other lab members while taking Dr. Janice Cooke's Plant Physiology course, and before I knew it, I had completed 3 separate independent research projects looking at plant defense compounds called phenolics. These projects laid the groundwork for what would become my graduate thesis, starting first as an MSc student in 2015 and transitioning to the PhD program the following summer.

A large portion of my thesis work focused on the role of phenolics in pine defenses against the mountain pine beetle-associated pathogen, *G. clavigera*, funded in part by the TRIA-Net Project. Through TRIA-Net I was fortunate to meet many wonderful colleagues and some of my best friends. I was also incredibly lucky in that I was able to incorporate lab and field work into my research, and I am grateful for the freedom I've been given to lean into some areas where I unexpectedly found passion, such as coding and data visualization. Despite the long dark of the past few years due to COVID-19, I successfully defended my PhD this past summer in June 2022. I started my position as the TRIA-FoR University of Alberta Project Manager the following month. Although I haven't been in the PM position long, I am already excited by all the work everyone is doing and I'm looking forward to playing a role in making that work happen.

In addition to work, I like to spend time with my partner, Ethan, and our large pumpkin (cat) Goose. We recently welcomed a new baby to our family in form of a 29-lb (and counting) puppy named Daphne, who takes all my remaining energy but also gives cuddles like no other. I enjoy spending time outside and love taking long bike rides, but am also always down for a movie, popcorn, and some cross-stitching. I'm currently teaching myself how to sew, which may serendipitously help me replace some of my puppy-ripped wardrobe. TBD on whether everyone will be getting pyjama pants as gifts this year.

Research Group Spotlight

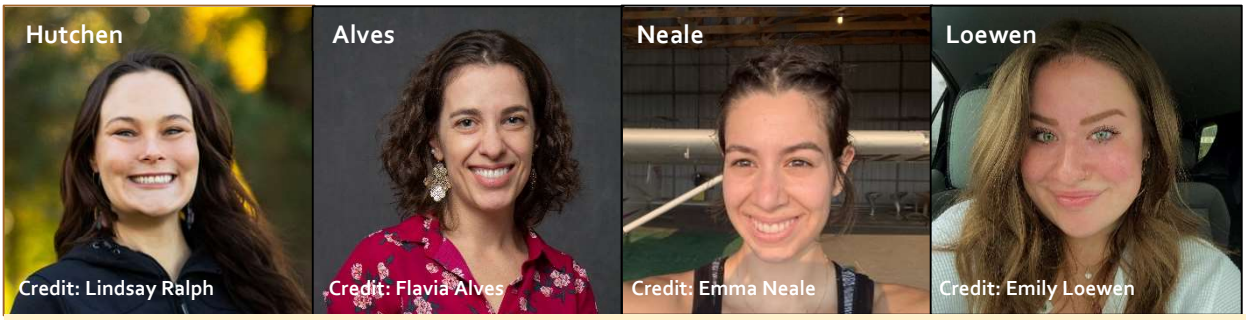
GE³LS Research Group (Drs. Vivian Nguyen and Stephan Schott) – Carleton University:

Credit: Lindsay Ralph (both)

The GE³Ls team, based out of Carleton University, is engaged in a range of research activities and collaborative work to address the social, economic, and policy dimensions of Mountain Pine Beetle management. While some individuals are leading project components, there is a tremendous amount of project component integration, and all contribute to each other's research through regular team meetings. **Dr. Vivian Nguyen**, one of the two GE³Ls co-leads, is an Assistant Professor at the Institute of Environmental and Interdisciplinary Science and the Department of Biology. Her research focuses on the interface of science, society, and policy within the themes of conservation, natural resource management (including fisheries and forestry), and food insecurity. Dr. Nguyen also has expertise in the human dimensions of environmental issues and mobilizing ecological knowledge into decisions, policy, and practice. The second GE³Ls co-lead, **Dr. Stephan Schott**, is a Professor in the School of Public Policy and Administration, with a background in Natural Resource and Environmental Economics. He has worked extensively in interdisciplinary teams with indigenous governments and communities, natural scientists, engineers, and other social scientists. His research currently focuses on food security and Northern fisheries, common pool resource institutions, forestry governance and mountain pine beetle management, alternative energy and sustainable development in the Arctic, wildlife management and knowledge co-evolution, and energy strategies and carbon emission reduction programs in North America and Europe.

Credit: Lindsay Ralph (both)

The two co-leads have been assisted by two senior Postdoctoral Fellows. **Dr. Valerie Berseth** is an environmental sociologist working in the areas of climate adaptation, conservation, and natural resource management. Her work investigates the meaning and value of wildness, and the ways that people understand and manage the risks of human interventions into nature, with a particular focus on genomic science and technology. She completed a Ph.D. in Sociology at the University of British Columbia and is a Postdoctoral Fellow in the Department of Geography and Environmental Studies at Carleton University. **Dr. Christopher J. Orr** seeks to understand how societies can better govern complex environmental challenges in Canada and globally. He recently co-edited Liberty and the Ecological Crisis: Freedom on a Finite Planet (Routledge). Dr. Orr is currently a Postdoctoral Fellow at the University of Waterloo.



Several graduate students are key contributors to the GE³LS effort. **Jenna Hutchen** is a PhD Candidate in Interdisciplinary Biology with Dr. Nguyen. Her research uses Social Network Analysis to understand how knowledge users access, value, and use knowledge about mountain pine beetle when making management decisions. Outside of academia, you can find her hiking, knitting, trying craft beers, or hanging out with her very old cat. **Flavia Alves** is a PhD candidate in Public Policy at Carleton University, with a focus on the impact of telecommunication technologies on banking and labour. She is a senior editor for the journal Carleton Perspectives on Public Policy and has worked in the past year as a Teacher Assistant in courses related to environmental policy. She volunteers as a Guide's leader and as an ESL teacher to disadvantaged students from her home country. **Emma Neale** is a PhD Candidate in the School of Public Policy and Administration. Her research interests are in multi-disciplinary projects to combine economic, social and technical knowledge to enhance policy decisions. **Emily Loewen** is a fourth-year undergraduate student in Dr. Nguyen's Social Ecology lab. She is completing her undergraduate thesis examining how the Mountain Pine Beetle crisis is framed in the media and looking for connections between the subsequent policy and management responses. Outside of school she loves to read, daydream, and spend time connecting with family and friends.

This GE³LS team is engaged in several integrated research activities. The Knowledge Mobilization effort (Jenna Hutchen, Valerie Berseth, Vivian Nguyen) has targeted how knowledge related to Mountain Pine Beetle is exchanged between experts, decision-makers, rightsholders, and stakeholders. In addition, they are identifying barriers that make it difficult to coordinate across jurisdictions and respond quickly to forest disturbances. The Policy Analysis effort (Chris Orr, Stephan Schott, Vivian Nguyen) has traced the different phases of MPB crisis response provincially in British Columbia, Alberta, Saskatchewan, and nationally. Recent team addition Emily Loewen works with Nguyen, Berseth, and Hutchen to study how these policy responses have been framed in news media coverage. To understand how people perceive the risks, benefits, and trade-offs of different forest management strategies, Berseth, Emma Neale, and Stephan Schott are planning community-based workshops with diverse rightsholders and stakeholders in focal areas of the project. Finally, to understand the risks of MPB for recreational forest users, Flavia Alves is studying the value of provincial parks for visitors, and their willingness to pay for more intensive management. From these combined efforts of the GE³LS team, the key deliverables will be the creation of tools for addressing communication, social, economic and regulatory factors that impact social acceptance and end-user adoption of genomics-informed applications related to the MPB outbreak. It is anticipated that this framework will enable more informed, trust-based, rapid decision-making, and adjustment of management practices.

In the News

Any TRIA-FoR-associated media reports since the previous newsletter are listed below, with links included if available.

CBC Radio One (June 9, 2022)
Title: Why is there so much pollen this year?
Radio interview with Janice Cooke and others on how climate change impacts pollen release.
Link: https://www.cbc.ca/news/canada/edmonton/pollen-western-canada-1.6483620

CBC Edmonton News (June 21, 2022).
TV interview with Janice Cooke and others.
This interview discussed how climate change could send Canada's boreal forest creeping north.
Link: https://www.cbc.ca/player/play/2056817219717

Carleton University Office of the Vice-President (Research and International) Web Article (June 17, 2022).
Title: Mountain Pine Beetle Genome Project to Assess Future Risk of Spread Across Canada.
Interview (Ellen Tsaprailis) with Catherine Cullingham, providing a project description/update.
Link: https://research.carleton.ca/story/mountain-pine-beetle-genome-project-to-assess-future-risk-of-spread-across-canada/

CBC Edmonton News (December 11, 2022).
Title: Mountain pine beetle populations down by 94 per cent in Alberta since 2019: province.
Interview with Janice Cooke, discussing the declining numbers of MPB in Alberta.
Link: https://www.cbc.ca/news/canada/edmonton/mountain-pine-beetle-populations-down-by-94-per-cent-in-alberta-since-2019-province-1.6677642

Publications

TRIA-FoR builds upon the wealth of pine and mountain pine beetle information generated during the earlier TRIA 1, TRIA 2, and TRIA-Net efforts. Several recent publications by team members focused on the work leading into and impacting this current project.

McAllister, C., Cullingham, C., Peery, R., Mbenoun, M., McPeak, E., Feau, N., Hamelin, R., Ramsfield, T., Myrholm, C., Cooke, J.E. 2022. Evidence of coevolution between *Cronartium harknessii* lineages and their corresponding hosts, lodgepole pine and jack pine. Phytopathology. https://doi.org/10.1094/PHYTO-09-21-0370-R

Presentations

Conferences Presentations

Insect Biotech Conference. Niagara on the Lake, ON, June 1-3, 2022

Haider, F., MacMillan, H. Energy metabolism of mountain pine beetles and emerald ash borer during diapause. Department of Biology, Carleton University, Ottawa, ON.

North American Forest Genetics Society Inaugural Meeting, Pacific Grove, CA. June 14-16, 2022.

Cooke, J. Not just lucky: Lodgepole pine survivors of mountain pine beetle outbreaks share a genomic signature for resilience. Department of Biology, University of Alberta, Edmonton, AB. *Opening Plenary Talk.*

Cullingham, C. Differential introgression of putative adaptive loci across the mosaic lodgepole x jack pine hybrid zone. Carleton University, Ottawa, ON.

Ecological Society of America (ESA)- Canadian Society of Ecology and Evolution (CSEE) Joint Annual Meeting, Montreal, QC. August 14-19, 2022.

Duffy, J., Akbar, M., Cullingham, C.I. Updated predictive model of the genetic structure of the lodgepole × jack pine hybrid zone. Carleton University, Ottawa, ON.

Hutchen, J., Berseth, V., Nguyen, V.M. Knowledge networks as a tool for integrating evidenced-based decision-making in forest pest management. Carleton University, Ottawa, ON.

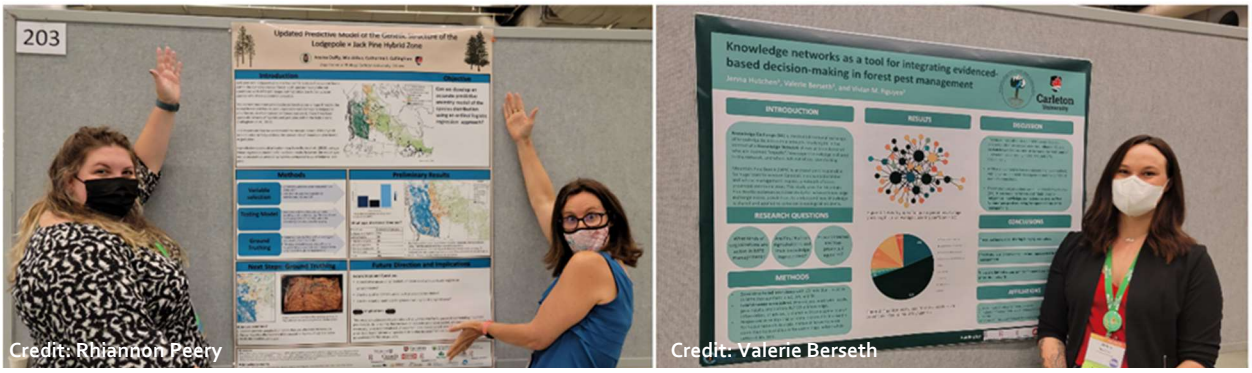
Yaremchuk, D.D., Cullingham, C.I., Peery, R. Evidence of local adaptation driving differential introgression between the extents of the mosaic lodgepole X jack pine hybrid zone in western Canada. Carleton University, Ottawa, ON.

Entomological Society of America (ESA), Entomological Society of Canada (ESC) and Entomological Society of BC (ESBC) Joint Annual Meeting (EntSoc 2022), Vancouver, BC. November 13-16, 2022.

Musso, A.E., Carroll, A.L., Evenden, M.L. Think of the children! Female host preference and offspring performance of mountain pine beetle in lodgepole and jack pines. University of Alberta, Edmonton, AB. ***Note: First Place Prize, Grad P-IE: Behavior and Pollinators**

Petro, L.N., Musso, A.E., Evenden, M.L. Building an appetite: energetic condition and host orientation in the mountain pine beetle. University of Alberta, Edmonton, AB.

Wu, Y., Evenden, M.L. Adult mountain pine beetle metabolism: Effect of beetle body condition and flight on adult mountain pine beetle *Dendroctonus ponderosae* Hopkins (Coleoptera: Curculionidae: Scolytinae) metabolic rate. University of Alberta, Edmonton, AB.



Poster presentations at the joint ESA-CSEE 2022 meeting. Grad student Jessica Duffy (left, Cullingham Lab), with Co-Lead PI Catherine Cullingham (centre), and grad student Jenna Hutchen (right, Nguyen Lab).

65th Annual Forest Pest Management Forum, Ottawa, ON. December 6-8, 2022.

Hutchen, J., Berseth, V., Nguyen, V. Using social network analysis to understand how mountain pine beetle information is exchanged across jurisdictions. Carleton University, Ottawa, ON.

Orr, C., Nguyen, V., Schott, S. Comparing policy approaches to mountain pine beetle outbreaks in Canada. Carleton University, Ottawa, ON.

Canadian Mathematical Society Annual Meeting, Toronto, ON. December 2-5, 2022.

Brush, M., Lewis, M. Modelling long term mountain pine beetle dynamics with changing tree resilience. University of Alberta, Edmonton, AB.

Fields Institute for Research in Mathematical Sciences - Workshop on Advances in Mathematical Ecology, Toronto, ON. December 6-7, 2022.

Brush, M., Lewis, M. Modelling long term mountain pine beetle population dynamics. University of Alberta, Edmonton, AB.

Departmental Seminar

Heath MacMillan. A physiological house of cards: The causes and consequences of iono-regulatory collapse in chilly bugs. Department of Integrative Biology, UC Berkeley. May 5, 2022.

Recent Achievements

Congratulations to Dr. Heath MacMillan (Carleton University) for his recent election as Director of the Entomological Society of Ontario. Additional congratulations to Dr. Maya Evenden (University of Alberta), who received the Entomological Society of America 2022 Science Communication Award for her Bugs 101 MOOC (Massive Open Online Course). This award was one of several showcased during the recent EntSoc 2022 meeting in Vancouver, BC. https://entsoc.org/news/press-releases/2022-awards

Acknowledgements

First Nations Land Acknowledgement

The various TRIA-FoR University researchers are based at institutions located on traditional/ancestral First Nations lands. As such, we respectfully offer these acknowledgements:

1) UBC Vancouver is situated in the traditional, ancestral and unceded territory of the xʷməθkʷəy̓əm (Musqueam).
2) The University of Alberta acknowledges that it is located on Treaty 6 territory, and respects the histories, languages, and cultures of First Nations, Métis, Inuit, and all First Peoples of Canada, whose presence continues to enrich our vibrant community.
3) Carleton University acknowledges the location of its campus on the traditional, unceded territories of the Algonquin nation. In doing so, Carleton acknowledges it has a responsibility to the Algonquin people and a responsibility to adhere to Algonquin cultural protocols.
4) Western University acknowledges that it is located on the traditional lands of the Anishinaabek, Haudenosaunee, Lūnaapéewak and Attawandaron peoples, on lands connected with the London Township and Sombra Treaties of 1796 and the Dish with One Spoon Covenant Wampum. This land continues to be home to diverse Indigenous peoples (First Nations, Métis, and Inuit) who are recognized as contemporary stewards of the land and vital contributors of our society.

Funding & Support

Funding for this research is being provided through grants to the TRIA-FoR Project from Genome Canada, the Government of Alberta through Genome Alberta, and the Ontario Research Fund – Ontario Ministry of Colleges and Universities through Ontario Genomics. Additional contributions are coming from the University of Alberta, Carleton University, Western University, the University of British Columbia, the Canadian Wood Fibre Centre – Natural Resources Canada, the Great Lakes Forestry Centre – Natural Resources Canada, West Fraser, Canfor, Alberta Ministry of Forestry, Parks and Tourism, fRI Research, and the Forest Improvement and Research Management Branch - BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

In addition to financial support, we also acknowledge the various samples and/or data sets or other information being generously provided through the Forest Improvement and Research Management Branch - BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Alberta Forestry, Parks and Tourism, the Saskatchewan Ministry of Environment, the Department of Environment and Natural Resources - Government of Northwest Territories, the Forestry Branch - Manitoba Agriculture and Resource Development, and the Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry.

We would like to acknowledge several specific individuals and organizations for their recent contributions to the project. We would like to thank High Country Arborist Services Ltd. (Edson, AB) for their services helping us to collect MPB materials for Activity 1. They were extremely helpful, especially for the second harvest, which was planned very last minute. In addition, we would like to thank Alberta Forestry, Parks, & Tourism (AFPT) Forest Health Officers (Devin Abraham, Andrea Sharpe, Pam Melnick) and Caroline Whitehouse for their help with summer field work and supply of data as part of the AFPT co-funding support. Finally, we would like to thank Dr. Amanda Roe and her GLFC team for the training and work they are providing for the MacMillan lab as part of the co-funding support for TRIA-FoR.

Newsletter Contributions: Flavia Alves, Valerie Berseth, Barry Flinn, Colleen Fortier, Jenna Hutchen, Emily Loewen, Emma Neale, Vivian Nguyen, Stephan Schott.
Artwork Credit: Kaylen Brzezinski.


Credit: Serita Fudlosid