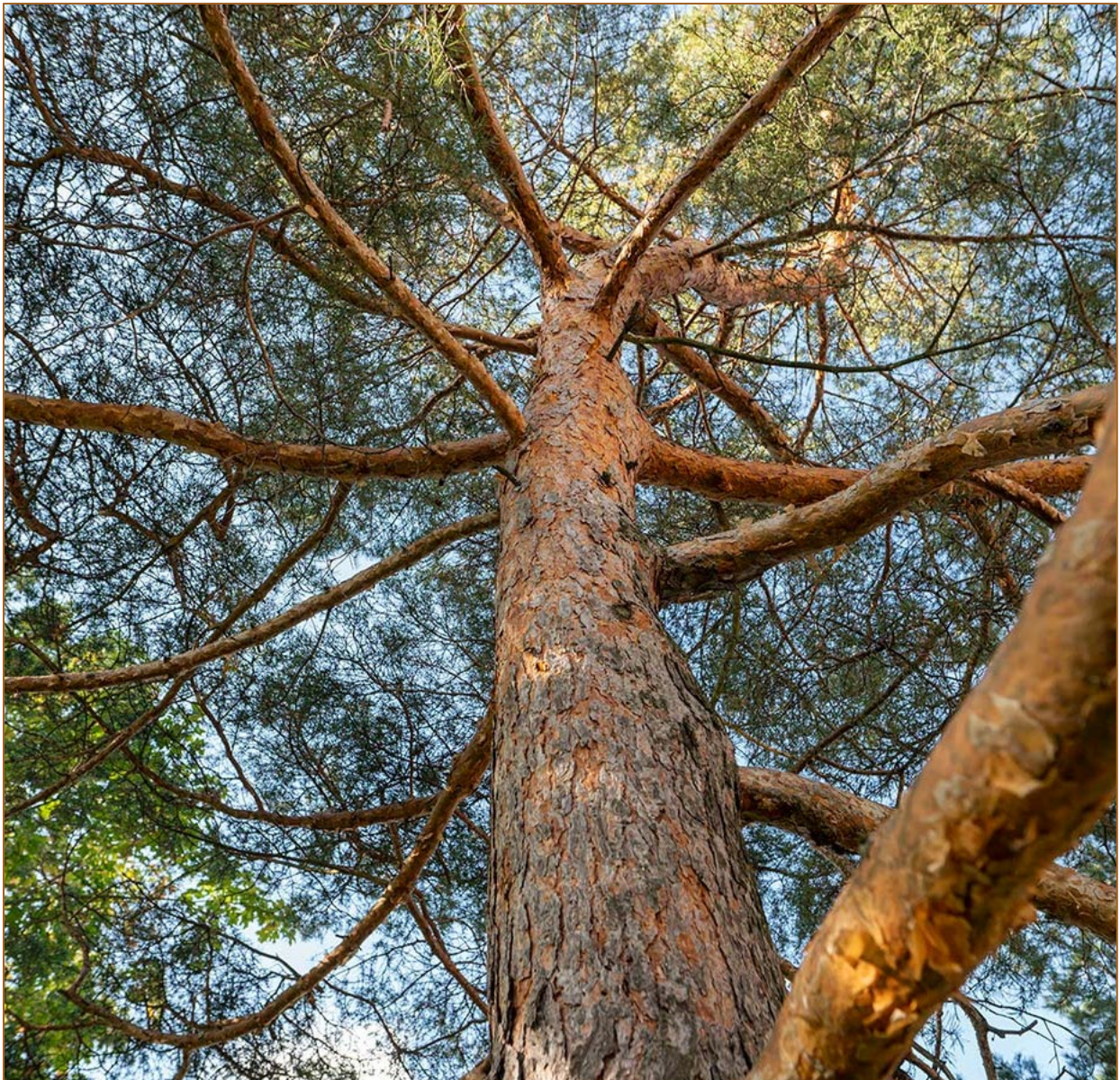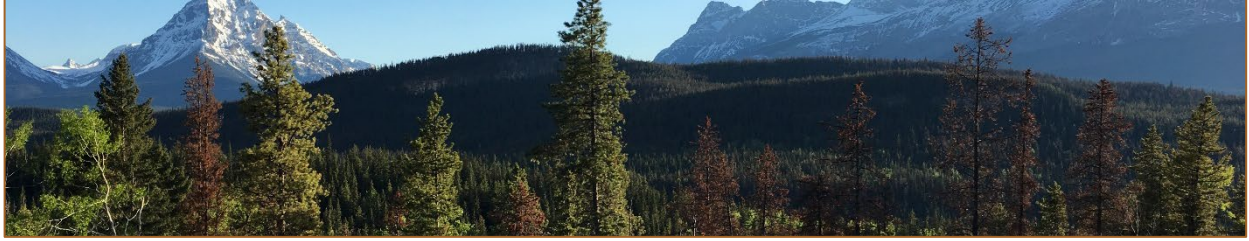# TRIA-FoR: Transformative Risk Assessment and Forest Resilience Using Genomic Tools for the Mountain Pine Beetle Outbreak

Newsletter

What's New?

As TRIA-FoR completes its first six months of operations, the team finds itself gearing up for the first full field research season. Moving forward, our aim is to provide a brief update on project progress with a focus on the specific research activities associated with the project.

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 MPB samples 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 few months, we have updated our pine sample database to highlight regions where additional geographic samples will be required for pine sampling. In terms of MPB (*Dendroctonus ponderosae*) sampling, we have numerous samples of *Dendroctonus* species collected from various habitats to be used in comparative studies, and infested bolts were sent to our Ontario researchers for use in preliminary assay and protocol development.

In our effort to understand **Activity 2 - Lodgepole pine genetic resilience to MPB**, we're using population and quantitative genomics 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. We've initiated candidate gene cloning for genes we've previously identified as being associated with resilience to MPB, as well as started new analyses to identify additional genes whose expression is correlated with pine MPB resilience or susceptibility. In addition, we've developed

an initial model to help us predict the impact of planting MPB-resilient lodgepole pine on MPB outbreak potential, incorporating information on tree defense mechanisms and MPB productivity and aggregation as model parameters.

A major component of TRIA-FoR targets the potential eastward spread of MPB across the boreal forest of Canada, using jack pine as host. To study this, we are assessing spread risk using both pine and MPB contributions. 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. Recently, we generated a new predictive model of lodgepole, jack and lodgepole x jack pine hybrid host distribution, which is under comparison with the previous model to assess for increased accuracy of host distribution. Additional genotyped pine samples from defined regions, as well as previously unsampled regions, are currently being used to help validate model predictions, as well as indicate regions of model uncertainty. In addition, to help characterize the genic and transcribed regions of jack pine associated with responses to MPB attack, several jack pine transcriptomes have been assembled and are currently under analysis for future mapping to the loblolly pine reference genome.

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. To date, field collected samples of MPB were used to develop preliminary protocols for physiological studies and metabolite analyses, as well as to isolate DNA for comparative genome analyses for the different *Dendroctonus* species collected from various habitats. Initial MPB metabolic baseline and flight behavioural studies are in progress and low temperature tolerance studies have been initiated. Additional insect species and collaborations have been added to allow for comparative low temperature tolerance studies with MPB.

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. To date, using various connections made during earlier fieldwork, the GE³LS team has now completed interviews with people involved in MPB management and decision-making at the regional, provincial, and federal level across British Columbia, Alberta, Saskatchewan, Manitoba, and Ontario. In these interviews, data was collected on formal and informal network connections, knowledge exchange practices, and types of knowledge (i.e., scientific, Indigenous, or local knowledge) used by decision-makers to create a social network of MPB management in Canada. This will provide a clear picture of how different types of knowledge and information about MPB, and its risk are used by provincial and federal levels of government to direct management actions.

The GE³LS team also conducted a media framing analysis of MPB coverage in Alberta and British Columbia. The purpose of this study is to gain an understanding of the narratives presented to non-scientists during the MPB outbreaks, and how those narratives changed over time. This provides important historical context for how people today understand and assess the risks of present and anticipated MPB outbreaks.

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. Working closely with the two institutional Co-lead PIs, various committees (Executive, Stakeholder and End-User Advisory, Communications, Data Management), the research team and Genome Alberta, both PMs share responsibility for logistics, finances, and human resources, with one PM (Carleton) leading TRIA-FoR communications initiatives, while the other (UAlberta) will oversee the TRIA-FoR data management plan. To date, the Carleton-based PM was hired just prior to the start of the project, and the UAlberta-based PM has been hired, and will start in July 2022. We have established a Carleton-based document/information sharing portal, and data storage and sharing capabilities are under development. The Communications team has created a TRIA-FoR Twitter account (https://twitter.com/TriaFor), as well as a Newsletter to aid in project dissemination efforts, and has also developed an outline of ideas for future project promotional engagement. One outcome of successful project communications will be the translation of knowledge generated by the project into deliverables that can be taken up and used by partner, stakeholder and end-user communities. As part of this effort, a Stakeholder and End-User Committee (SEAC) was recruited, and a SEAC Terms of Reference document was created. In addition to the SEAC, contributions were made to the development and completion of the Annotated Bibliography for the TRIA Network as well as to the completion of the archiving of publicly accessible versions of all of these papers at the University of Alberta Education and Research Archive (ERA). These efforts have provided the groundwork for TRIA-FoR data management and knowledge sharing.

New Team Member Introduction

Dr. Fouzia Haider (MacMillan Research Group – Carleton University):

I was born and brought up in Dhaka, the capital of Bangladesh. Coming from a family of doctors, I also hoped to become a doctor; however, the entrance exam did not approve of that. I changed my focus and carried out Bachelor's and Master's studies on Geography and Environmental Science at the University of Dhaka. After finishing my Bachelor's degree, I began applying for scholarships abroad. While completing my Master's degree, I was selected for a joint European Master's program funded by the Erasmus MUNDUS Scholarship, to study Marine Environment and Resources (MER) in 2013. Once my Master's thesis in Dhaka was finished, I flew to Spain to begin my second Master's degree, with travel to France and Belgium for the following semesters. I met many nice people and learned many new things regarding life and work during this time. For my research, I joined Dr. Inna Sokolova at the University of Charlotte, in North Carolina. After completing my thesis with Dr. Sokolova and my MER degree, I moved to Germany with Dr. Sokolova where I interviewed and was unanimously chosen for a PhD candidacy on a new project. During this effort, I studied the effects of environmental and anthropogenic stressors on the bioenergetics and mitochondrial physiology of marine molluscs (bivalves).

Having completed my MSc and PhD theses with Dr. Sokolova , I decided it was time to spread my wings on my own. As I searched for postdoctoral offers worldwide, I had the opportunity to travel to the United States, as well as many countries of Europe. I was longing to come to Canada, and luckily for me, Dr. Heath MacMillan had an opening for a postdoctoral fellow to study the bioenergetics of overwintering in Mountain Pine Beetle (MPB). After a formal interview, I was offered the postdoctoral position, and could not have been more excited! I started to work at Carleton University in January 2022 and am currently conceptualizing the project and setting up the protocols. With these little steps one at a time, I am paving my way to becoming a famous researcher in the field of bioenergetics and mitochondrial physiology.

But that's not all to me! I am also a fun-loving person who enjoys experiencing new cultures, new languages, and new food. I love to travel around the world, and to hike up mountains. Thanks to the pandemic, I had a chance to hone my indoor hobbies, which include paper crafting and baking. At present my favorite pastime is to curl up in my cozy couch under a blanket with a hot cocoa or a coffee and enjoy freshly baked goods and the Ottawa weather! I like to enjoy the little moments of life, despite the adversity that comes along.

Research Group Spotlight

Lewis Research Group – University of Alberta:

Dr. Mark Lewis is Canada Research Chair in Mathematical Biology at the University of Alberta. He has pioneered the development of models for mountain pine beetle dynamics and risk and has been a long-time collaborator on TRIA networks. He is an enthusiastic participant in the network and appreciates the great benefit of being part of a truly interdisciplinary research group that TRIA-FoR provides. His overall goal is to undertake top level quantitative modelling and analysis that connects directly to important questions in ecology and management, and the collaborative structure of TRIA-FoR is a key ingredient. Lewis' primary focus in TRIA-FoR is to analyze MPB outbreak potential under different scenarios of lodgepole pine resiliency (Activity 2.3), to model spatial spread-risk of eastwardly spreading MPB (Activity 3.3) and to model the effect of the full overwintering temperature profile on MPB fitness, and whether these effects are pronounced in novel habitats mechanistic models (Activity 4.1). As a co-PI on the previous TRIA-Net network, Lewis had the opportunity to recruit and train some exceptional HQP (e.g., Devon Goodsman, Dean Koch, Melodie Kunegel-Lion, and Nathan Marculis), and much of the work in TRIA-FoR builds upon their (https://era.library.ualberta.ca/search?search=Lewis+AND+%28Marculis+OR+Goodsman+OR+Koch+OR+Kunegel-Lion%29) results. To date, Lewis has recruited two HQP (Micah Brush and Xiaoqi Xie) and is in discussion with one more to join the team as a PhD student.


Dr. Micah Brush is a postdoctoral fellow in the Lewis Research Group at the University of Alberta in the Department of Mathematical and Statistical Sciences, broadly interested in theoretical and spatial ecology. He is currently working on modelling mountain pine beetle dynamics and has other projects in macroecology and biodiversity. He completed his PhD in physics at UC Berkeley with Prof. John Harte studying how ecological disturbance affects macroecological patterns, and before that did his MASt (Part III) at Cambridge University, and his undergrad in physics at Simon Fraser University. Micah is also involved in other issues in higher education, and as a graduate student served as a co-coordinator for Respect is Part of Research, a peer-led sexual harassment/sexual violence prevention program that reached hundreds of incoming graduate students each year in STEM. Outside of academics, Micah enjoys hiking, singing, and baking, and is very happy to be curling again now that he is in Edmonton.

Currently, Micah is working on the spatial modelling of eastern spread-risk of mountain pine beetle (TRIA-For Activity 3.3). He is developing a new mathematical model for this purpose, building on previous modelling work undertaken via a previous research network (TRIA-Net), which combines mountain pine beetle dynamics and forest structure and tree resilience. This model captures

important aspects of mountain pine beetle biology, such as their local aggregation when attacking trees and their need to attack in large numbers to overcome tree defenses, and additionally describes pine forest growth. Micah's mathematical approach will allow modelling of pine beetle populations as it spreads eastward. This type of modelling is important to answer questions such as how resilient trees, whether naturally occurring or managed, will affect the spread of pine beetle, how long it will take forests to recover after infestation, and how management strategies will affect mountain pine beetle population dynamics in the long term. The longer-term goal is to incorporate this modelling into software development based on the SpaDES platform and to share results with end-users and stakeholders interested in management and outcomes.
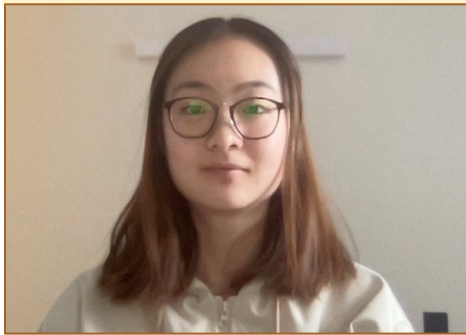
Xiaoqi Xie is an MSc student in Applied Mathematics and a member of the Lewis Research Group. She started her position in September 2021. Xiaoqi completed her BSc degree at the University of Manitoba, with a major in Statistics Actuarial and a minor in Business Management. As an undergrad student, Xiaoqi studied sampling under the supervision of Dr. Brad Johnson at the University of Manitoba, and to share results with end-users and stakeholders interested in management and outcomes.

Currently Xiaoqi is looking forward to work on modelling MPB outbreak potential under different scenarios of lodgepole pine resiliency (TRIA-For Activity 2.3). She is taking courses and preparing by surveying the literature in this area and reading key papers. Her goal is to develop models to address the proportion of resilient trees required to slow MPB population dynamics sufficiently to provide additional time for control measures to be deployed and become effective. She expects to use methods from statistics, machine learning (e.g., Bayesian belief models) and dynamical systems for this research. The longer-term goal is to communicate the results to end-users and managers who can incorporate the results into making predictions and choosing management strategies.

In the News

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

CBC Edmonton Evening News (Dec. 30, 2021).
TV interview with Janice Cooke.
This interview dealt with the effect of the current cold spell on MPB populations in Alberta.
Link: https://www.cbc.ca/player/play/1988627011807/

CBC Edmonton Late News (Dec. 30, 2021).
TV interview with Janice Cooke.
This interview dealt with the effect of the current cold spell on MPB populations in Alberta.

CNN – The Lead with Jake Tapper (Feb. 10, 2022)
Television interview (Bill Weir) with Janice Cooke regarding the climate impact on price of lumber.
Link: https://twitter.com/theleadcnn/status/1491919081557090304?s=21

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.

White B, Flinn B, Odsen S, Rubuliak N. 2022. Annotated Bibliography for the TRIA Network. fRI Research, 106 pp. Published online January 12, 2022.
https://friresearch.ca/resource/annotated-bibliography-tria-network

Chiu CC, Bohlmann J. 2022. Mountain Pine Beetle Epidemic: An Interplay of Terpenoids in Host Defense and Insect Pheromones. Annual Review of Plant Biology 73:9.1–9.20.
https://doi.org/10.1146/annurev-arplant-070921-103617

Upcoming Conferences

Insect Biotech Conference. Niagara on the Lake, ON. June 1-3, 2022.
https://paluzzi.lab.yorku.ca/ibc/

North American Forest Genetics Society Inaugural Meeting. Pacific Grove, CA. June 14-16, 2022. https://treegenesdb.org/nafgsconference

American Society of Plant Biologists/Canadian Society of Plant Biologists Joint Meeting. Plant Biology 22. Portland, OR. July 9-12, 2022. https://plantbiology.aspb.org/

Ecological Society of America/Canadian Society for Ecology and Evolution Joint Meeting. ESA CSEE 2022. Montréal, QC. August 14-19, 2022. http://www.csee-scee.ca/category/meetings/upcoming-csee-meetings/

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.

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Newsletter Text: Barry Flinn, Valerie Berseth, Jenna Hutchen, Fouzia Haider, Mark Lewis, Micah Brush, Xiaoqi Xie.
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