Workshop #2

Physiological Responses, Climate Change, Chemical Defenses to Stress and Economics/Wood Optimization

December 2, 2020

****The presentations will be available by December 11, 2020 on the RES-FOR website under the RESOURCES tab. https://resfor.ualberta.ca/resources/**

**** Our infographics and highlight sheets can also be found on our website:**

https://resfor.ualberta.ca/resources/highlight-1/

https://resfor.ualberta.ca/resources/res-for-infographics/

RES-FOR Virtual Showcase II Agenda

Date: December 2, 2020

Title: RES-FOR Virtual Showcase II
Location: Your Computer: Zoom Link
Date: December 2, 2020 9 am to 1:30 pm
Chair: Barb Thomas **IT**: Stacy Bergheim

Start	End	Time	Item	Contact
9:00 AM	9:10 AM	0:10	Brief introduction to RES-FOR project	Barb Thomas
9:10 AM	9:20 AM	0:10	Physiology/Climate/Chemical Ecology & Economists behind the RES-FOR project	Barb Thomas
9:20 AM	9:50 AM	0:30	The economics of genomic assisted tree breeding in Alberta	Henry An
9:50 AM	10:20 AM	0:30	Optimization & utilization of wild versus improved trees - a test case	Julie Cool
10:20 AM	11:05 AM	0:45	Tree rings and drought, what does it tell us?	Jaime Sebastian Azcona
11:05 AM	11:15 AM	0:10	BREAK	
11:15 AM	12:00 PM	0:45	Physiological responses in pine and spruce, adults and seedlings	Xiaojing Wei
12:00 PM	12:30 PM	0:30	Metabolomic responses - can they help us with selections?	David Wishart
12:30 PM	1:15 PM	0:45	Chemical defense responses in pine and spruce - winners and losers	Jennifer Klutsch
1:15 PM	1:25 PM	0:10	Wrap up	Barb Thomas
1:25 PM			Adjournment	
Total		**4:25**		

RES-FOR Background and Key Achievements, Fall 2020

Prepared by: Barb Thomas, Project Lead: bthomas@ualberta.ca and
Stacy Bergheim, Project Manager: sberghei@ualberta.ca Website: https://resfor.ualberta.ca/

The RES-FOR project, *Resilient Forests – Climate, pests and policy, genomic applications* – was funded in 2016 through the 2015 Genome Canada LSARP program – (Large Scale Applied Research Project) – for $5.6M.

1. Funding and co-funding has been diverse across sectors. There are 4 Universities, 13 investigators and 4 forest company partners.
2. This is a 4-year project, of which we are in the 4th year, with a roll-out of deliverables in a series of workshops on September 16, 2020 (#1), December 2, 2020 (#2) & January 21, 2021 (#3) - in conjunction with Tree Improvement Alberta, in Edmonton.

The goals of this project were to take two tree improvement programs in Alberta, one spruce (Region D1, GoA), and one pine (Region C, Industry), and apply the tools and state of the art analysis to pilot the application of genomics and genomic selection. This project has also included many components well beyond just genomics such as:

- Comprehensive phenotyping of progeny trial & greenhouse trial trees associated with the Region D1 & C programs
- A comprehensive economic analysis with an add-on module for tree improvement in GYPSY
- A conjoint study of selection trait trade-offs for mill use
- An optimization study for maximizing fibre utilization
- Social science surveys of community perceptions to genomics technology
- Internal interviews with the members of the RES-FOR team on technology application
- Development of communication tools and scenario mapping of uptake outcomes

The core genomics work, has included the following:

- Sampling at 3-4 progeny trials for each program acting as the 'training populations' for development of new genomics based models selecting for core traits (eg: ht, DBH, Western Gall Rust)
- Taking approximately 17,000 measurements of phenotypic data from the progeny trials across traditional and non-traditional traits (eg: height, wood density, resin ducts, physiology etc.)
- The DNA sequencing of the ~ 3,200 RES-FOR trees in the progeny trials (a subset of low, medium & high productivity families and progeny based on height performance at ~ age 30yrs; 40 pine & 80 spruce families)
- The reanalysis of all the progeny trial data incorporating an enhanced spatial analysis, and refined pedigree information that was revealed through the DNA sequencing
- Building of genomic models linking phenotype (eg: height) with genotype (ie: the genetic DNA sequence) while optimizing the number of genetic markers (SNPs, single nucleotide polymorphism) needed to produce the most robust models
- Conducting a large greenhouse trial to test both drought and insect resistance in both species (ie: MPB and spruce budworm), using half the families phenotyped/genotyped in the field progeny trials, providing the 'validation population' for the models
- For the pine, 15 phenotypes (including core traits) are being analyzed in various combinations to provide new rankings for forward selections based on genomic estimated breeding values
- For the spruce, a new reference genome was accessed during the project therefore all data is being reanalyzed using this additional high quality DNA sequencing information
- A program called 'Shiny' has been used to develop an interactive selection tool for program manager to use the new breeding values to make informed decisions for the next generation of forward selections.

<u>This program will provide information as follows:</u>

- Recommendations will be made for the 2nd generation forward selections in each program – based on a series of different rankings (based on selected traits) – **end-users can decide how they want to implement and can run their own scenarios for selection options using Shiny**.
- Genomic models and new breeding values will be available for future selection in these programs.
- Advancement to the 3rd generation orchards can be made much more rapidly by conducting breeding of selected progeny trial trees, and then sequencing the seedlings from those crosses and applying the genomic models to predict their phenotypes – THIS IS THE STEP IN GENOMIC SELECTION THAT ELIMINATES OR REDUCES THE NEED FOR A GENERATION OF PROGENY TESTING. The selected individuals can then be grown for a period of time and subsequently grafted into an advanced 3rd generation orchard.

There is a need for understanding policy in light of these potential changes, that allows for rankings to be made through genomic based models with new genomic estimated breeding values, application of genomic selection and location, management and access to the digital DNA sequences. An investment in people also needs to be recognized.

Barb Thomas – RES-FOR Lead

Barb is a Professor in the Department of Renewable Resources at the University of Alberta (UofA), Edmonton, Canada. She holds a BSc and MSc from UBC (Agriculture/Forest genetics) and a PhD in Forest Biology and Management from the UofA. Prior to her current position, Barb worked in the Alberta forest industry for ~20 years as an industrial scientist working with poplars, in government policy and in knowledge exchange.

Barb came to the UofA in 2014 with an NSERC Industrial Research Chair in Tree Improvement, which is now in its second 5-year term. The research in Barb's lab is focused on answering primarily applied questions addressing challenges facing breeding programs in Alberta. Barb is interested in linking ecophysiological and growth responses to abiotic stress (drought), and providing information to practitioners on results application. Other areas of study include determining the mechanisms underlying low conelet retention in lodgepole pine seed orchards, development of new age-age correlations and growth models for incorporating genetic gain and climate change into growth and yield models, assisting with new breeding designs to maximize growth and understanding the impact of pollen contamination in seed orchards. More fundamental research interests include understanding the trade-offs in the distribution of trembling aspen on the landscape relative to gender and resource availability. This question is being addressed through phenotypic, ecophysiological and genomic assessments.

This LSARP grant, was a huge opportunity to bring a unique set of experts together to test and showcase the potential of applying and integrating cutting-edge genomic technologies into Alberta's tree improvement programs. It has been an honour to lead this team and I am extremely proud of all the outcomes and deliverables that we have produced. Alberta has the prospect of embracing these results and working towards applying them across all programs to meet climate change face-on, integrating decision making with silvicultural foresters and Government policy makers.

Nadir Erbilgin – RES-FOR Co-lead

Ecology and Management of Emerging Forest Pest Problems: Forest Health Impacts of Insect Outbreaks in Western Canada

Dr. Nadir Erbilgin is a Professor in Forest Entomology & Chemical Ecology in the Department of Renewable Resources. He is currently serving as an Associate Chair-Research and The Director of the Field Research Office. He received his PhD from the University of Wisconsin-Madison, worked as a Postdoctoral Research Fellow at the University of California-Berkeley, and joined the University of Alberta as a Canada Research Chair in 2007. His research program focuses on the adaptive responses of forest trees to biotic (e.g., insects and pathogens) and abiotic (e.g., drought) stressors. Specifically, his research group characterizes the changes in tree conditions in response to biotic and abiotic stressors and how these changes in turn affect the health of forests. Giving that emerging pest problems are causing wide-spread forest decline, investigations on the causes of pest invasions have become more critical than ever. Dr. Erbilgin has developed a new framework describing why some tree species, and thus forests, are more vulnerable to pest invasions but not others. This framework successfully explained the establishment of several forest pest species in North America.

Julie Cool – RES-FOR Co-applicant

Julie's area of interest is wood machining and process optimization in both the primary and secondary wood manufacturing sectors. Her overall research objective is to provide sound scientific results using both fundamental and applied research that can be easily translated to the wood industry to increase wood recovery and product quality which directly impacts revenues and local economies.

Julie also believes that it is important to better link forest management and silvicultural practices to the end-user's needs in order to improve raw material allocations, focus on market-pull operations and foster product innovations and development based on specific wood properties and the corresponding wood processing techniques. As the pressure on forest lands constantly increases, this area of research could benefit both large-scale industries and small rural communities.

Julie holds an undergraduate degree in Mechanical Engineering from the Université Laval as well as an MSc and PhD in Wood Science. Following her studies, Julie worked as a scientist at FPInnovations and as a consultant. Her research combines applied and fundamental projects and focuses on the link between tree/wood quality and how best to process changing raw materials for specific objectives or end-products.

Henry An – RES-FOR Co-applicant

Henry An is an Associate Professor and Associate Chair (Graduate Studies) in the Department of Resource Economics and Environmental Sociology (REES) at the University of Alberta. He is primarily interested in examining the economics of technology adoption with a focus on biotechnology and the agri-food sector. Some of his current research projects include: quantifying the economic impact of adopting blockchain technology in the beef and pork sectors, identifying incentives to encourage genomic information sharing among beef producers in Alberta, and investigating the factors influencing wheat variety adoption in the Canadian Prairies."

Henry lead the research within the RES-FOR project on the financial trade-offs in adopting genomic selection technology in tree improvement and is currently working with Thomas, on a con-joint study determining selection trade-offs related to tree quality/quantity when growing the next generation forests in Alberta.

David Wishart – RES-FOR Co-applicant

Dr. David Wishart (PhD Yale, 1991) is a Professor in the Departments of Biological Sciences and Computing Science at the University of Alberta. He is also a senior research officer and the director of the Nano Life Science program at the NRC's National Institute for Nanotechnology (NINT). He has been with the University of Alberta since 1995. Dr. Wishart has active research programs in Ua Colourstructural biology, nanobiology, synthetic biology, prion biology, bioinformatics and metabolomics. Some of his lab's most significant contributions have been in the area of protein chemical shift analysis and the prediction of protein structure.

The RES-FOR project has taken David's expertise in metabolomics and applied it to forest tree species.

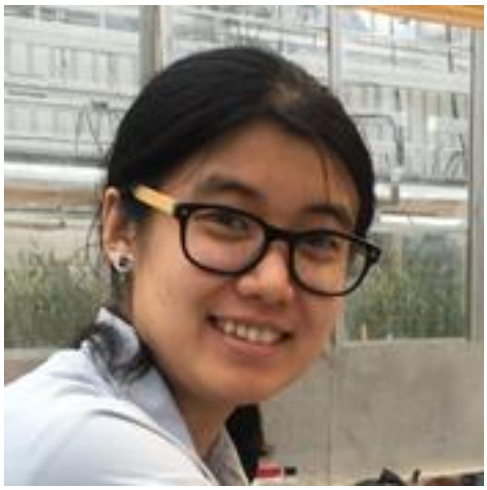
Shawn Mansfield – RES-FOR Co-applicant

Shawn Mansfield is a Canada Research Chair in Wood Biotechnology and Fibre Quality at the University of British Columbia. Shawn is a world-leading authority on plant secondary cell wall biosynthesis. He is internationally recognized for his efforts linking genomics, biochemistry, and development, and using functional genomics, has discovered genes critical to plant growth. His work has significant implications for the improvement of bioenergy crops and forest trees, with the potential to substantially ameliorate the anthropogenic footprint of industrial processing and mitigate atmospheric CO_2 release.

Andreas Hamann – RES-FOR Co-applicant

Andreas Hamann is a Professor in the Department of Renewable Resources at the University of Alberta. He received his PhD from UBC after an MSc at the State University of New York. Andreas's primary research fields are global change biology, genetics, and climate change adaptation with applications in forest ecology and management. He asks: How are tree species and their populations adapted to the environments in which they occur? How is the growth and health of natural tree populations and planted forests affected by climate change? How should we manage our forest resources under changing environments?

Xiaojing Wei – RES-FOR Postdoctoral Fellow (Thomas lab)



Xiaojing obtained her BS degree at the Department of Ecology at the China Agricultural University, and her PhD degree at the Department of Ecology, Evolution, and Behavior at the University of Minnesota, USA. Her research interest is the evolution of ecologically relevant traits in plants. One of the most exciting things she found working in the RES-FOR project is to combine her ecophysiology background in drought tolerance with quantitative genetics tools, and to learn how to think not only as an evolutionary biologist but also as a tree breeder.

Jennifer Klutsch – RES-FOR Postdoctoral Fellow (Erbilgin lab)

Jennifer Klutsch is a postdoctoral researcher working with Dr. Nadir Erbilgin at the University of Alberta. Her current research examines variation in tree defenses and identifies biomarkers for trees resilient to emerging insect pests and climate change threats as part of the Resilient Forests: Climate, Pests & Policy – Genomic Applications project. While completing her PhD at University of Alberta, she worked to improve monitoring tools to detect mountain pine beetle in the eastern edge of beetle expansion into the boreal forest and investigated the role of a forest pathogen in tree defenses and the performance of mountain pine beetle.

Jaime Sebastian Azcona – RES-FOR Postdoctoral Fellow (Thomas/Hamann labs)

Jaime Sebastian completed his Master's degree in AgroParisTech (France) and his PhD in the University of Alberta under the supervision of Uwe Hacke and Andreas Hamann. His research has always focused on the physiological adaptation of trees to climate, particularly to extreme drought and frost events. His research for the RES-FOR project explores the drought tolerance of lodgepole pine and white spruce utilizing a dendrochronology approach.

Sudarshana Bhumireddy – RES-FOR Postdoctoral Fellow (Wishart lab)

Reddy did his PhD in Analytical chemistry (Mass spectrometry) from the CSIR-Indian Institute of Chemical Technology (India) and has seven years of hands-on experience in LC-coupled mass spectrometers (Q-Exactive Orbitrap, QQQ, and Q-ToF) and GC-MS techniques for the identification/quantification of small molecules with sound knowledge of chromatography. Reddy is a postdoctoral fellow with David Wishart where his research focuses on optimization of extraction protocols for the targeted compounds from biological and plant samples and the development of fully quantitative LC and GC coupled mass spectrometry-based metabolomics assays for the analyses of primary and secondary plant metabolites from plant samples. Integration of chemical responses with the other phenotypic data and investigating underlying physiological pathways.