Workshop #3

Assessing and communicating uncertainties with genomic selection applications in forestry

January 21, 2021

ZOOM LINK:

RES-FOR & Tree Improvement Lab is inviting you to a scheduled Zoom meeting.

Topic: RES-FOR Communication and GE3LS Workshop

Time: Jan 21, 2021 10:00 AM Mountain Time (US and Canada)

Join Zoom Meeting

https://us02web.zoom.us/j/83223532276?pwd=cGo1d2NEWVdDUy9ObkpmZ3BsdUt1QT09

Meeting ID: 832 2353 2276

Passcode: 162303

Find your local number: https://us02web.zoom.us/u/kbMm7isVTn

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

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

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

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

https://resfor.ualberta.ca/publications/

RES-FOR Virtual Showcase II Agenda

Date: January 21, 2021

Title:	RES-FOR Virtual Showcase III
Location:	Your Computer: Zoom Link
Date:	January 21, 2021 from 10 am to 12:00 pm
Chair:	Debra Davidson and Gwendolyn Blue

Start	End	Time	Item	Contact
10:00 AM	10:10 AM	0:10	Introductions (Barb)	Barb Thomas
10:10 AM	10:25 AM	0:15	Intro/overview of Social Science GE3LS research; (Debra / Gwen)	Debra Davidson
10:25 AM	10:40 AM	0:15	Significance of uncertainty communication for forestry genomics	Gwendolyn Blue
10:40 AM	10:55 AM	0:15	Responses to uncertainty (Jam Board interactive session)	Gwendolyn Blue
10:55 AM	11:10 AM	0:15	Types of scientific uncertainty & Implications for Genomics	Debra Davidson
11:10 AM	11:55 AM	0:45	Questions about genomics & uncertainty (Jam board interactive session)	Debra and Gwen
11:45 AM	11:50 AM	0:05	Adjournment	Barb Thomas
Total		**2:00**		

RES-FOR Background and Key Achievements, Winter 2020/21

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, 4 forest company partners and the Alberta government.
2. This is a 4-year project, of which we are in the final year, with a roll-out of deliverables in a series of workshops held 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, comparing improved and unimproved trees
- 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, exploration of uncertainties 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 a program called 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 correlation 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.

Gwendolyn Blue – RES-FOR Co-applicant

Gwendolyn Blue is an Associate Professor in the Department of Geography at the University of Calgary (UofC) with appointments in the Faculty of Science Natural Science interdisciplinary program. Before joining the Department of Geography in 2011, she was an Assistant Professor in the Department of Communication and Culture at the UofC, and an instructor at the University of North Carolina, Chapel Hill and Elon University. Formally trained in the field of Cultural Studies, she conducts research in three interconnected areas: 1) public controversies involving science and technology; 2) public engagement with science and technology; and 3) political, cultural and ethical dimensions of scientific and technological innovations. Her research draws on post-structuralist traditions in science and technology studies (STS) and political ecology, and has examined the politics surrounding BSE (Bovine Spongiform Encephalopathy), local food, climate change, wildlife management and more recently, genomic applications for environmental issues. She is currently a collaborator on a SSHRC funded project examining Alberta and British Columbia's climate policies and is a member of the Genome Canada funded (RES-FOR) project team exploring the social and policy dimensions of genomic applications for climate change adaptation in forestry (GE^3LS).

For a more comprehensive overview of research, see ORCID 0000-0003-3510-3248.

Debra Davidson – RES-FOR Co-applicant

Debra J. Davidson is Professor of Environmental Sociology in the Department of Resource Economics and Environmental Sociology at the University of Alberta, having received her PhD from the University of Wisconsin (1998). Her key areas of teaching and research include impacts of and adaptation to climate change, and crises and transitions in food and energy systems. Dr. Davidson is a lead author in Working Group II of the Intergovernmental Panel for Climate Change's 5th Assessment Report. Her work is featured in several journals, including Science, Global Environmental Change, British Journal of Sociology, Society and Natural Resources, International Sociology, and Sociological Inquiry, among others. She is co-author of Challenging Legitimacy at the Precipice of Energy Calamity (2011), and Consuming Sustainability (2005).

Current Research Activities: Advancing Impact Assessment for Canada's Socio-Ecological Systems. Co-Lead Investigators Dr. Debra Davidson and Dr. Ian Stewart (Kings University). Social Sciences and Humanities Partnership Development Grant. Co-funder: Impact Assessment Agency of Canada. Funding: $652,000. 2020-2023. This interdisciplinary and collaborative research initiative includes participation of researchers and partner organizations across Canada. We are focusing on how we can address many of the most challenging issues facing impact assessment processes in Canada, including gender-based analysis, addressing Indigenous sovereignty, integrating multiple forms of knowledge, and emerging climate impacts.

Anthony Fisher – RES-FOR MSc completed in Jan. 2020 (Davidson)

Anthony holds a Master of Science (MSc) in risk and community resilience and a Bachelor of Science (BSc) in forestry; both were obtained from the University of Alberta. He completed his master's degree while working within the RES-FOR project where his thesis involved travelling to rural communities to engage with forest stakeholders on the use of genomic selection in tree breeding to identify and understand perceptions about this emerging technology. He is currently working as a research associate at Y Station in Edmonton.

Kristy Myles – RES-FOR MSc completed in Dec. 2020 (Blue)

Kristy recently completed the Natural Sciences and Engineering Research Council (NSERC)-CREATE program for Genome Editing for Food Security and Environmental Sustainability (GEFSES) at McGill University and her Masters in Geography, funded by the RES-FOR project, at the University of Calgary. Kristy brought her training in both the natural sciences and the interpretive social sciences to her research at RES-FOR where she examined the social dimensions of Genomic Selection (GS) development in forestry. This research aimed to create space for new kinds of conversations about, and opportunities to reflect on, the broader social implications of promising biotechnologies like GS.

Julie Cool – RES-FOR Co-applicant

Dr. Cool 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.

Julie is an Assistant Professor at the University of British Columbia and her current areas of interest are 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.

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, in 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.

What is GE^{3}LS*?

GE^{3}LS stands for:

G = Genomics and its

E^3 = Ethical, Environmental, Economic

L = Legal and

S = Social Aspects

It should be understood as research into the implications of genomics in society.

- ✓ Genomics has the potential to have significant social and economic impact.
- ✓ All Genome Canada LSARPs must undertake research into the *application and implications of genomics in society* (GE^{3}LS research) as either a major focus or an integrated component of the project.
- ✓ GE^{3}LS research should investigate aspects of responsible innovation in the natural resource and environment sectors, including for example: key factors that may facilitate or hinder the effective translation of research and the uptake of genomic-based applications.
- ✓ Outputs from the GE^{3}LS research should inform & help implement *changes in practices or policies* related to use of genomics research or enhance the understanding of the implications of genomics in society more broadly.
- ✓ Integrated GE^{3}LS research must address salient factors that will impact the *advancement and application of the project's genomics* research. The integrated GE^{3}LS research questions must be aligned with, and be complementary to, the overall project goals.

**GE^{3}LS research investigates questions at the intersection of genomics and society. It provides stakeholders the insights needed to anticipate impacts of scientific advances in genomics, avoid pitfalls, cultivate success, and ultimately, contribute to Canada's leadership in the 21st century global bioeconomy. GE^{3}LS researchers come from many disciplines in social sciences and the humanities, including business, law, communications, and public policy. They often help bridge gaps between genomics researchers and other stakeholders.' https://www.genomecanada.ca/en/programs/genomics-society-ge3ls*