



Update for CTAC  
April 2, 2020

**Sally Aitken, Project Leader**, UBC – Conifer genetics and genomics,  
climate change adaptation, climate-based seed transfer

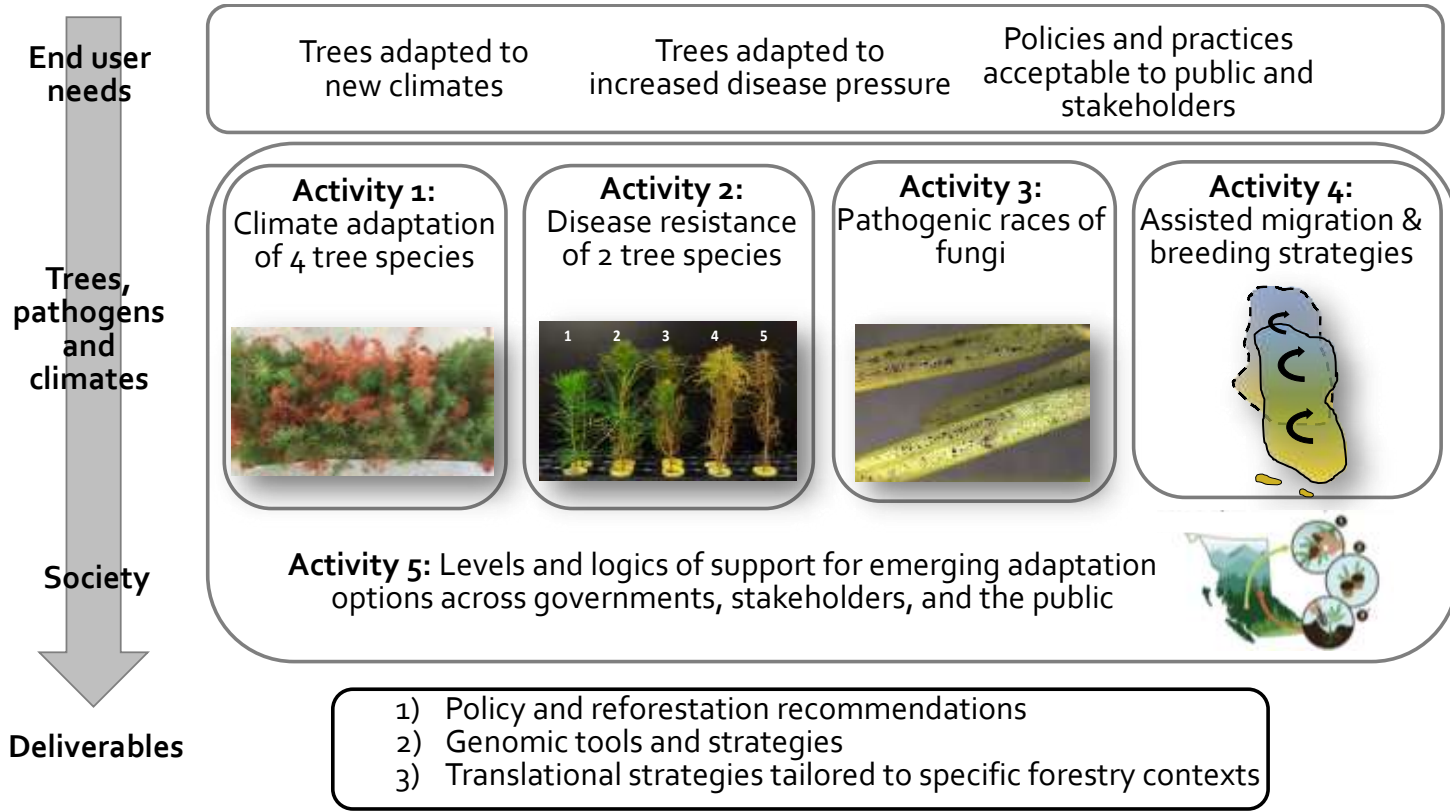
**Sam Yeaman, Project Co-Leader**, U Calgary – AIHS Chair in  
Bioinformatics and Computational Biology

**Richard Hamelin, Project Co-Leader**, U Laval & UBC – Forest pathology,  
fungal population structure, diagnostic markers

**Shannon Hagerman, GE<sup>3</sup>LS Co-leader**, UBC -- Socioecological systems

**Rob Kozak, GE<sup>3</sup>LS Co-leader**, UBC – Sustainable business management,  
communities and livelihoods, wood products

# Project Schematic



# Drought tolerance in Douglas-fir: Two experiments completed; genomic data being analyzed to identify candidate genes (R. Ribeiro)

May 2018 (≈45 days)



Jul 2018 (≈100 days)



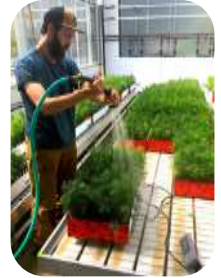
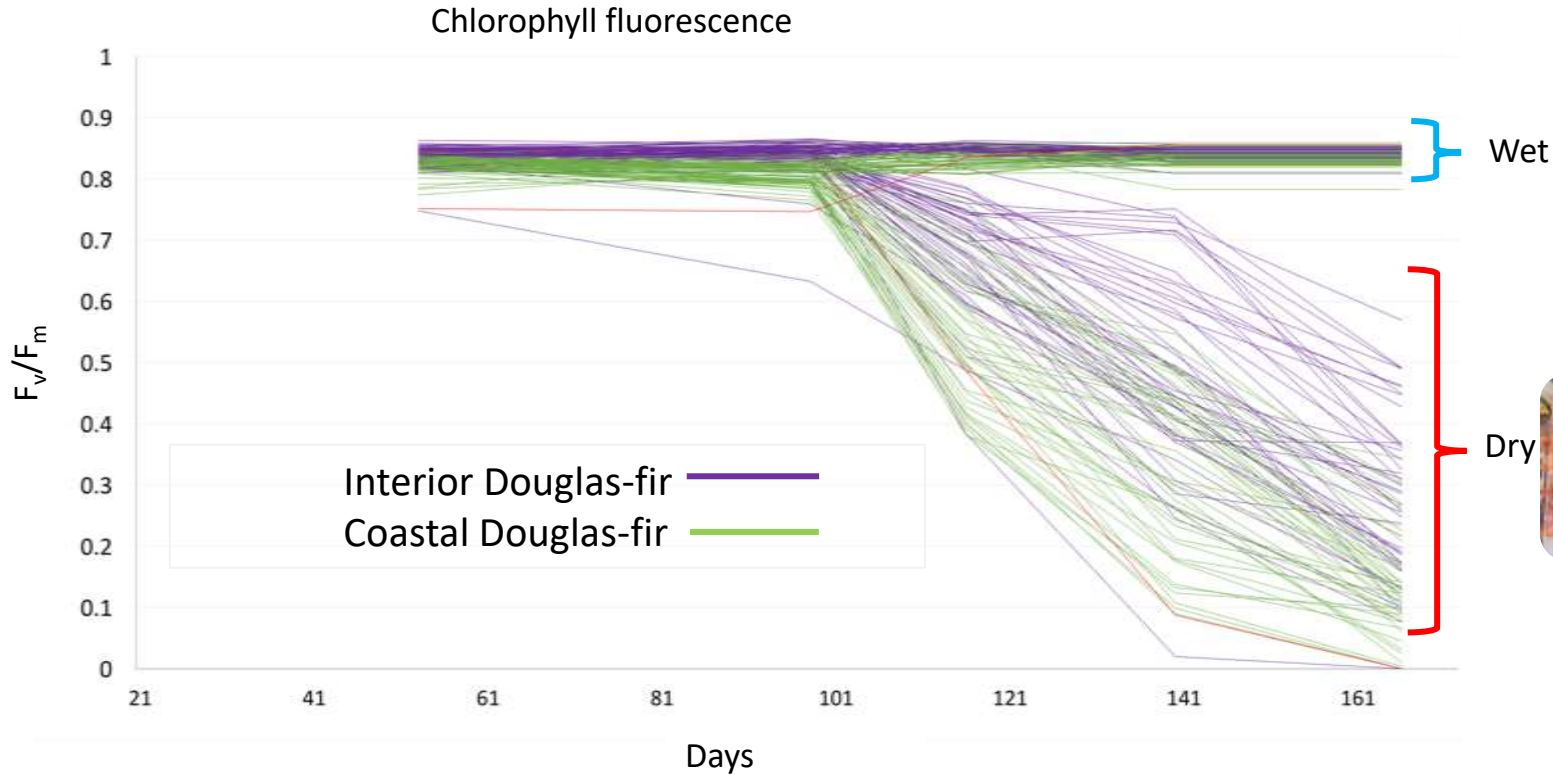
Aug 2018 (≈135 days)



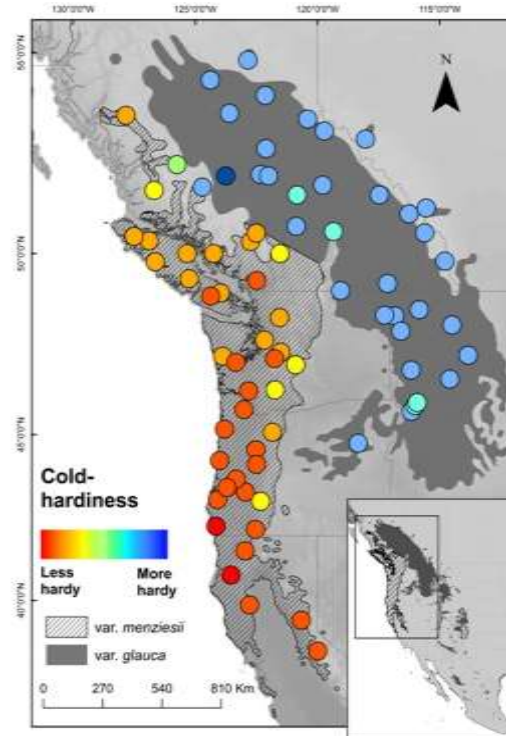
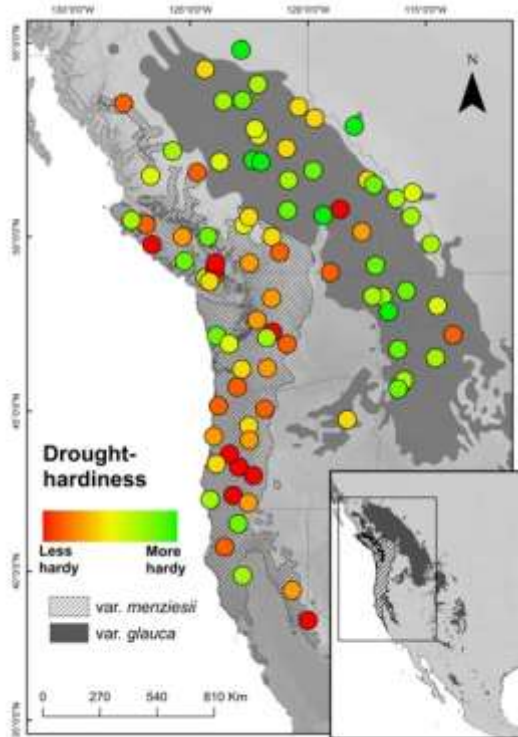
Sep 2018 (≈150 days)



# Experiment I: Drought tolerance of 87 populations (R. Ribeiro)

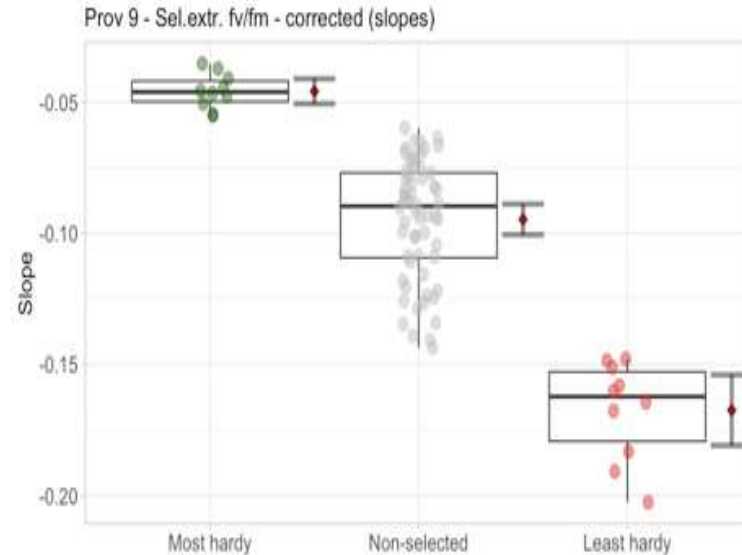
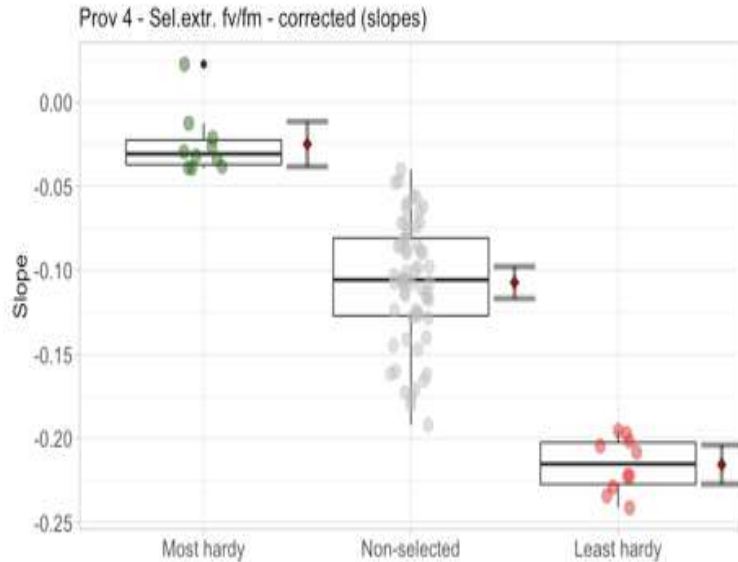


# Provenance variation within varieties stronger for cold hardiness than for drought tolerance



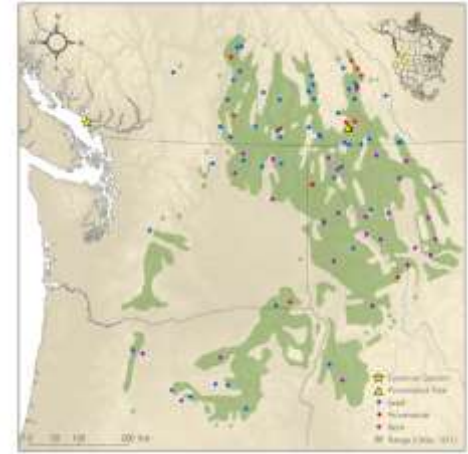
# Experiment II: Identification of genes associated with drought tolerance (R. Ribeiro and B. Lind)

- Case-control pools from 20 populations identified based on phenotypes
- Targeted capture libraries sequenced and awaiting analysis



## 1.2 – Climate adaptation in western larch (B. Roskilly, B. Lind)

- Seedlings grown from 40 natural populations and 30 full-sib select families (B. Roskilly).
- Seedlings being transplanted in April for phenotyping cold hardiness and drought tolerance, hopefully in 2020
- Currently analyzing genomic data for 40 populations for climate adaptation



## Activity 4.2 – Common gardens for marker validation and screening breeding population for cold and drought

- 45 FS families of **coastal Douglas-fir** from the third-generation breeding program sown in fall of 2018, transplanted spring of 2019;
- 56 full-sib families of **interior Douglas-fir** from the advanced-generation breeding program sown in spring of 2018 , transplanted fall 2018;
- Both experiments were phenotyped for cold hardiness in Oct 2019 (~1400 trees)
- Both experiments will have control and moderate drought treatments in 2020



*Cold hardiness  
phenotyping Oct. 2019*



## Activity 4.2 – Genomic tools for Douglas-fir and lodgepole pine breeding

- Have consulted with the breeders, and decided on a ~70,000 SNP Thermo Fisher Axiom array that includes both Douglas-fir and lodgepole pine SNPs for \$39 (or less)
- Will include markers for climate adaptation, cold hardiness, drought tolerance, disease tolerance (SNC, DNB)
- Will be genotyping materials from coastal Douglas-fir, interior Douglas—fir and lodgepole pine breeding programs with this array

# Act. 3.1 Genomic variability in tree pathogens (R. Hamelin)

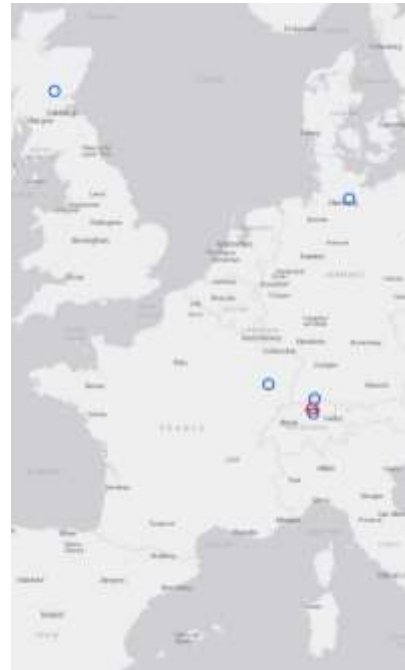


## 3.1.1 Build reference collections of Dothistroma needle blight



> 500 whole genomes from 4 continents, mostly from *Pinus* sp., few from *Picea* sp.

### 3.1.2 Build reference collections of Swiss needle cast

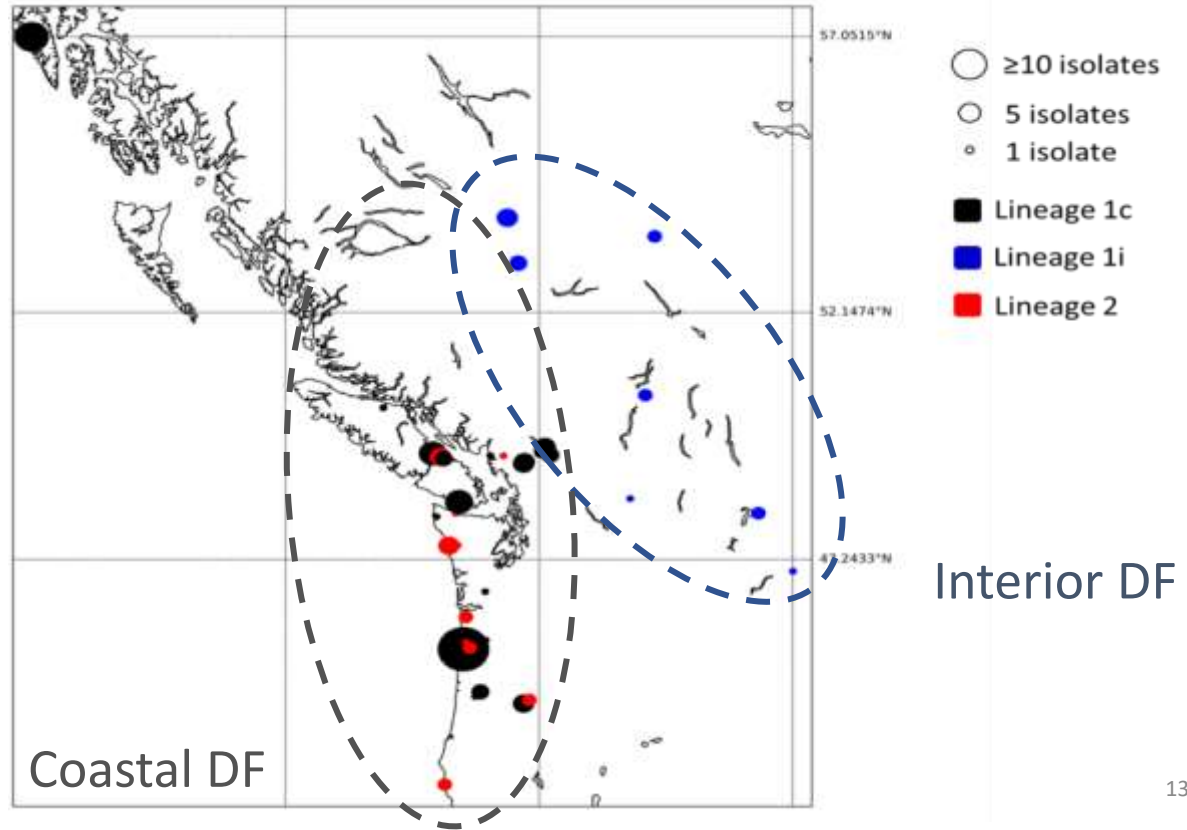


○ 1<sup>st</sup> plate (n=72)    ○ 2<sup>nd</sup> plate (n=96)

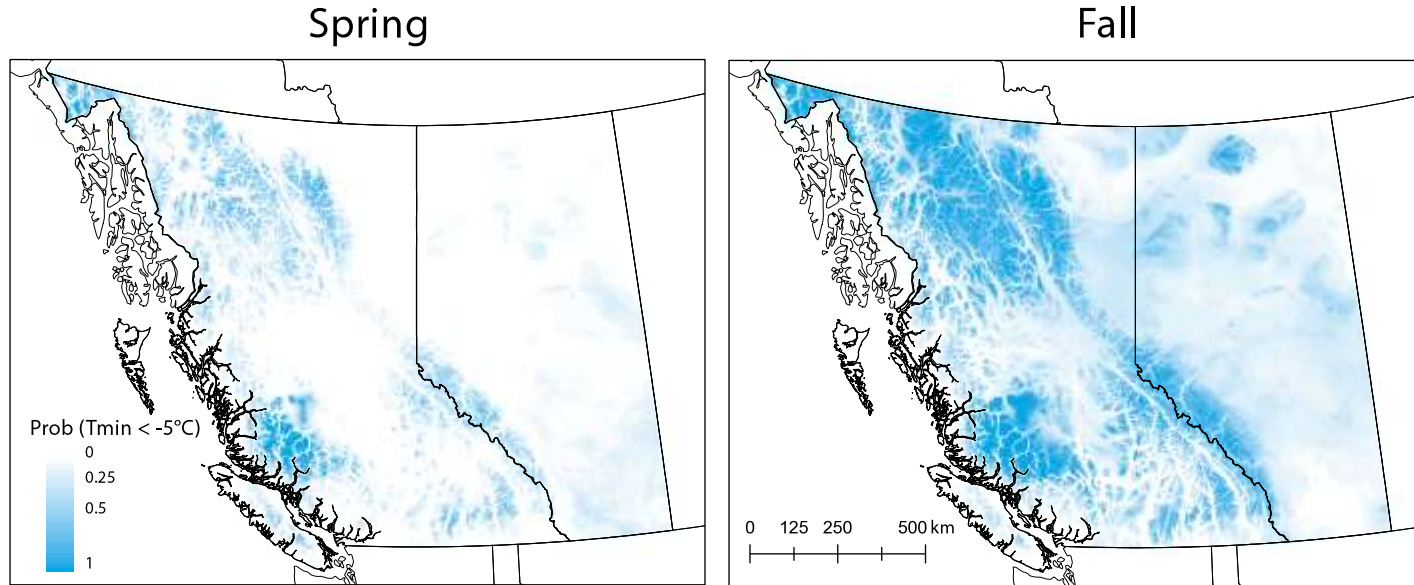
Over 1000 *Nothophaeocryptopus gaumannii* strains Alaska–OR, NM, Eastern U.S.A., Europe, New Zealand

### 3.1.4 Population genomic analyses of SNC

Diversification in Lineage 1 corresponds to host adaptation



## 4.1 Modelling risks of climate-based seed transfer: Diseases, cold, drought (Hamann, Sang, Simbaraju, Wang)



**Figure 4.1.2** Probability of experiencing a late spring frost or an early fall frost in any given year. Late spring frost events are defined as nights  $\leq -5^{\circ}\text{C}$  in a 30-day window following the day of year where growing degree days reach 100 (proxy for budbreak).

## Activity 2.1 and 4.2 – Common gardens for marker validation and translation: SNC tolerance in Douglas-fir

- Awaiting sequence data from case-control experiment for SNC using seed source movement study in OR, WA (B. St. Clair)
- Will use GCA/polymix progeny test for coastal Douglas-fir to validate candidate SNC tolerance markers from USFS trial (with Stoehr/Degner)



# GE<sup>3</sup>LS research: Canada-wide, web-based survey of experts (n=657)

- How do registered professionals (foresters and biologists) view assisted migration in Canada's forests (e.g. in terms of overall support, criteria for development and implementation)?

Province	Forestry experts	Biology experts
British Columbia	232	20
Quebec	199	15
Alberta	100	14
Ontario	23	8
New Brunswick	21	2
Others	29	4

- n = 531
- 78% male; 22% Female
- ~ years of experience = 21.6



# Six reforestation options (St. Laurent Hagerman, Kozak)

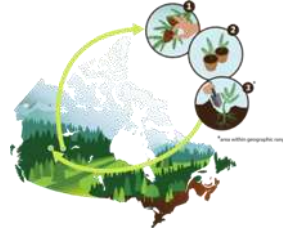
Reforestation strategies **currently used**

Natural regeneration



Reforestation strategies **currently being considered/implemented**

Assisted migration within native range



Reforestation strategies **not currently being considered**

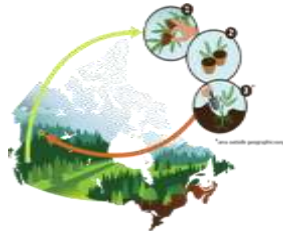
Reforestation with exotic species



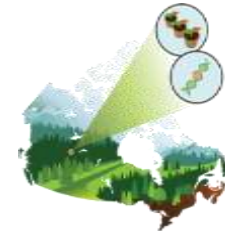
Tree breeding



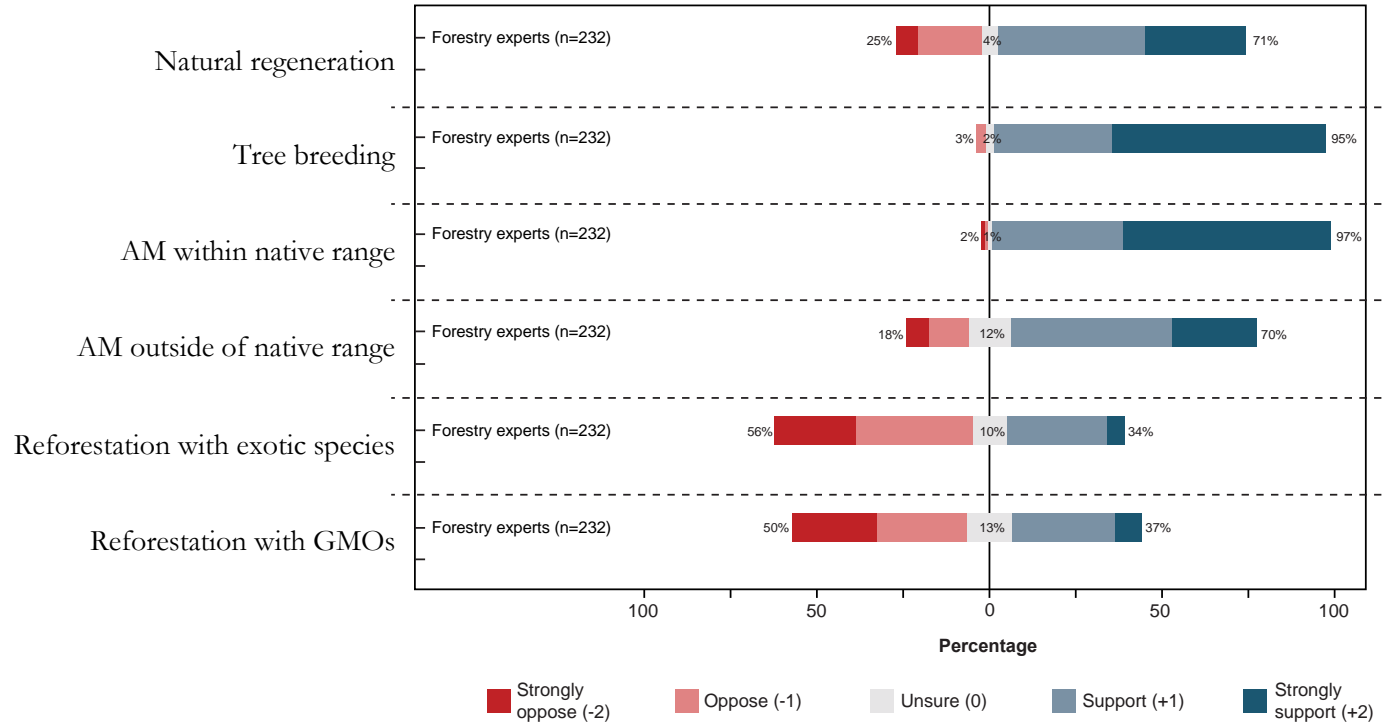
Assisted migration outside of native range



Reforestation with GMOs

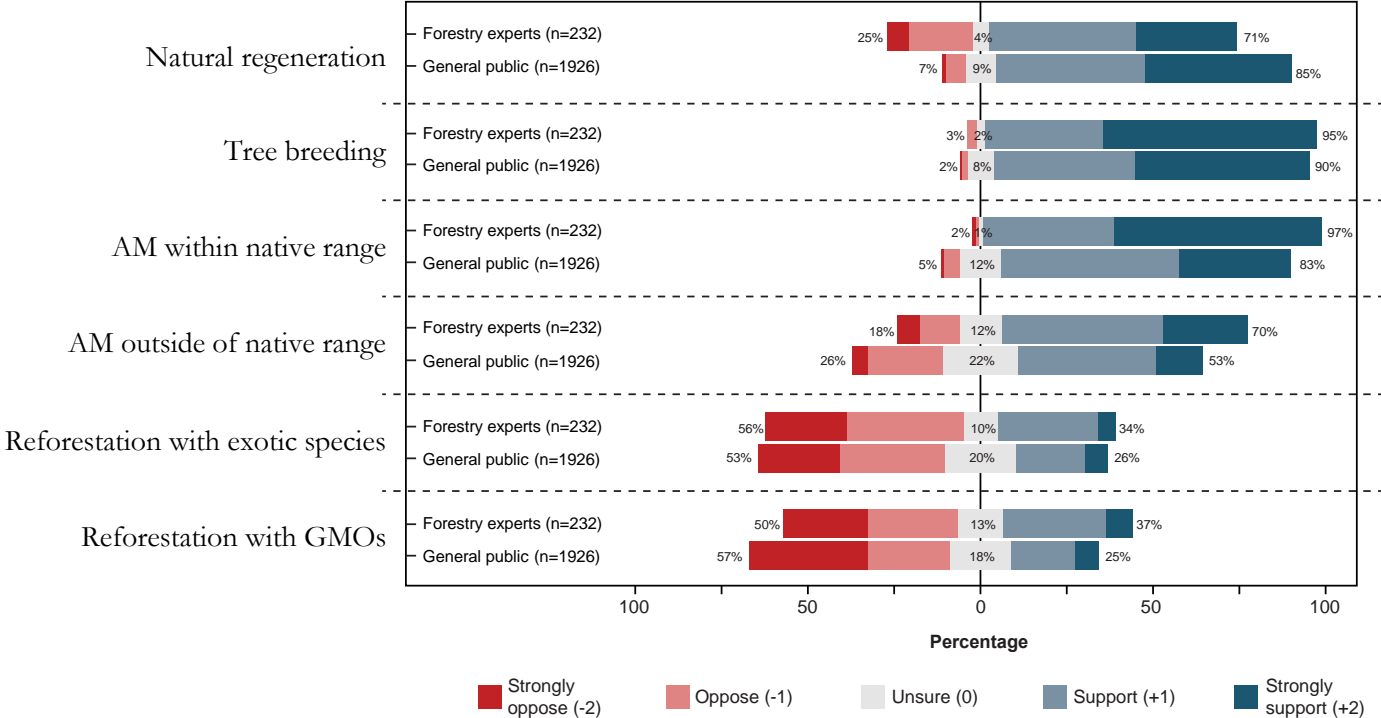


# Views of forestry experts (St. Laurent Hagerman, Kozak)



# Views of forestry experts & the general public in BC very similar

(St. Laurent Hagerman, Kozak)



# Project wrap-up

- End date of project is currently Sept. 30, 2020
- Have applied for a no-cost extension of up to one year
- SNP array for activity 4.2 won't be completed until June at the earliest
- Will need to keep key personnel for at least 9 months past current end date



Funding request from CTAC/ITAC for Douglas-fir and western larch climate adaptation (Activity 1), and screening families from breeding programs for cold and drought tolerance (Activity 4)

<b>Item</b>	<b>2020-21 request</b>
PhD student 1 - Douglas-fir adaptation	\$5,000
PhD student 2 - Western larch adaptation	\$5,000
Summer student - supplement to NSERC Summer Research Award	\$4,900
Greenhouse or Totem Field rental	\$1,740
Greenhouse and lab phenotyping supplies	\$2,000
Technician (0.2 FTE) for Douglas-fir and larch common garden experiments	\$8,710
Postdoctoral fellow 0.2 FTE	\$12,650
<b>Subtotal</b>	<b>\$40,000</b>
Overhead 25%	\$10,000
<b>Total</b>	<b>\$50,000</b>