FGC Forest Genetics Council of British Columbia

ITAC Extension Meeting – January 22 & 23, 2020

CoAdapTree

Healthy Trees for Future Climates

UBC Forestry University of British Columbia

Population variation for adaptation traits in Douglas-fir

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#CoAdapTree

Introduction

- Climate Change

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Healthy Trees for Future Climates

Introduction

- Local adaptation

Local adaptation mainly driven by cold temperatures

Drought is likely becoming one of the major drivers of adaptation

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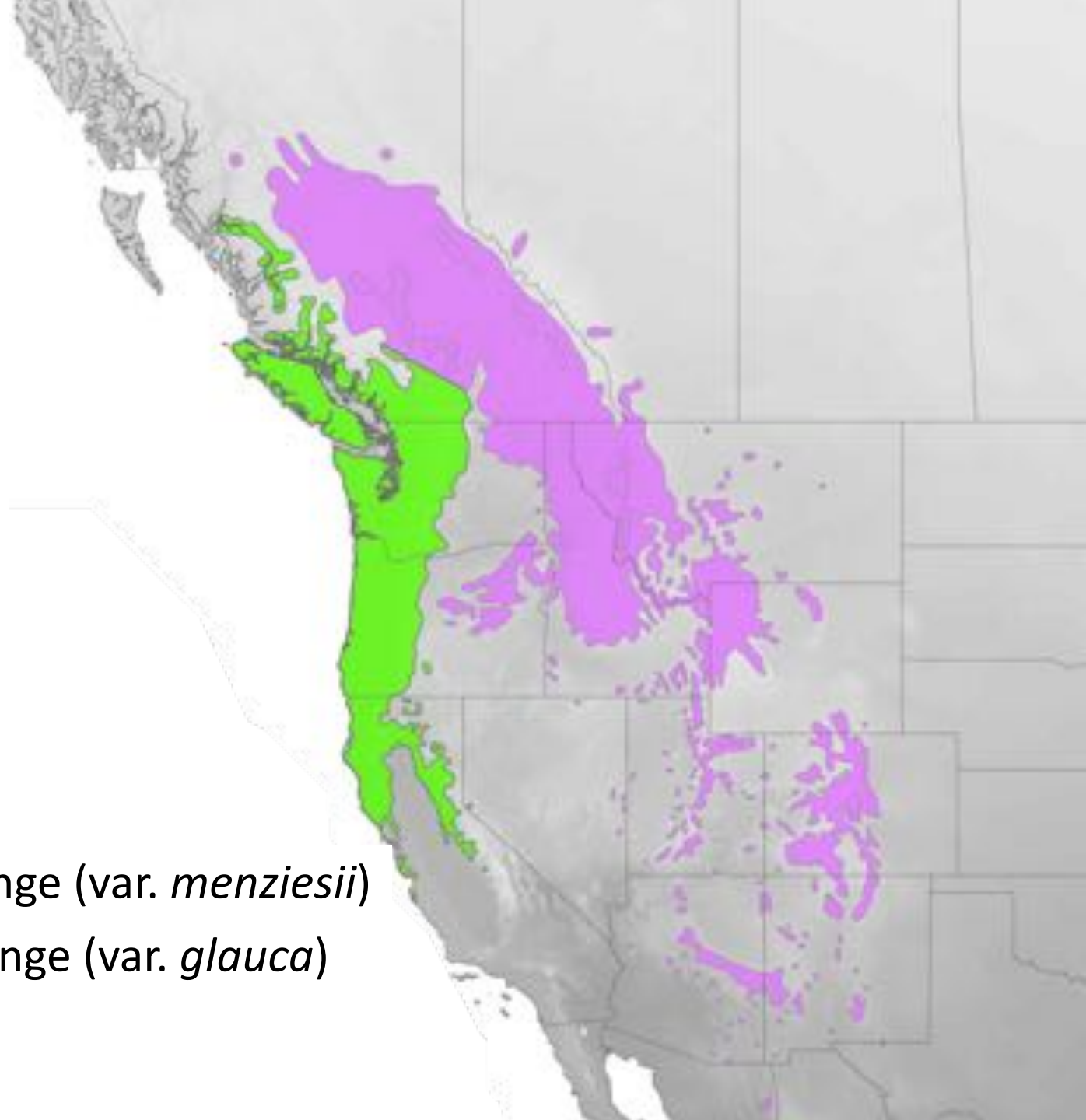
Introduction

- Douglas-fir (*Pseudotsuga menziesii*)



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Objectives

- Investigate the evolutionary potential of Douglas-fir to adapt to climate change
- Characterize levels of cold and drought hardiness in natural and breeding populations (seedlings)
- Describe the distribution of phenotypes and genotypes underlying these adaptations throughout the species' range
- In this sense, can we precisely prescribe assisted gene flow strategies that will better match genotypes with predicted future climates?

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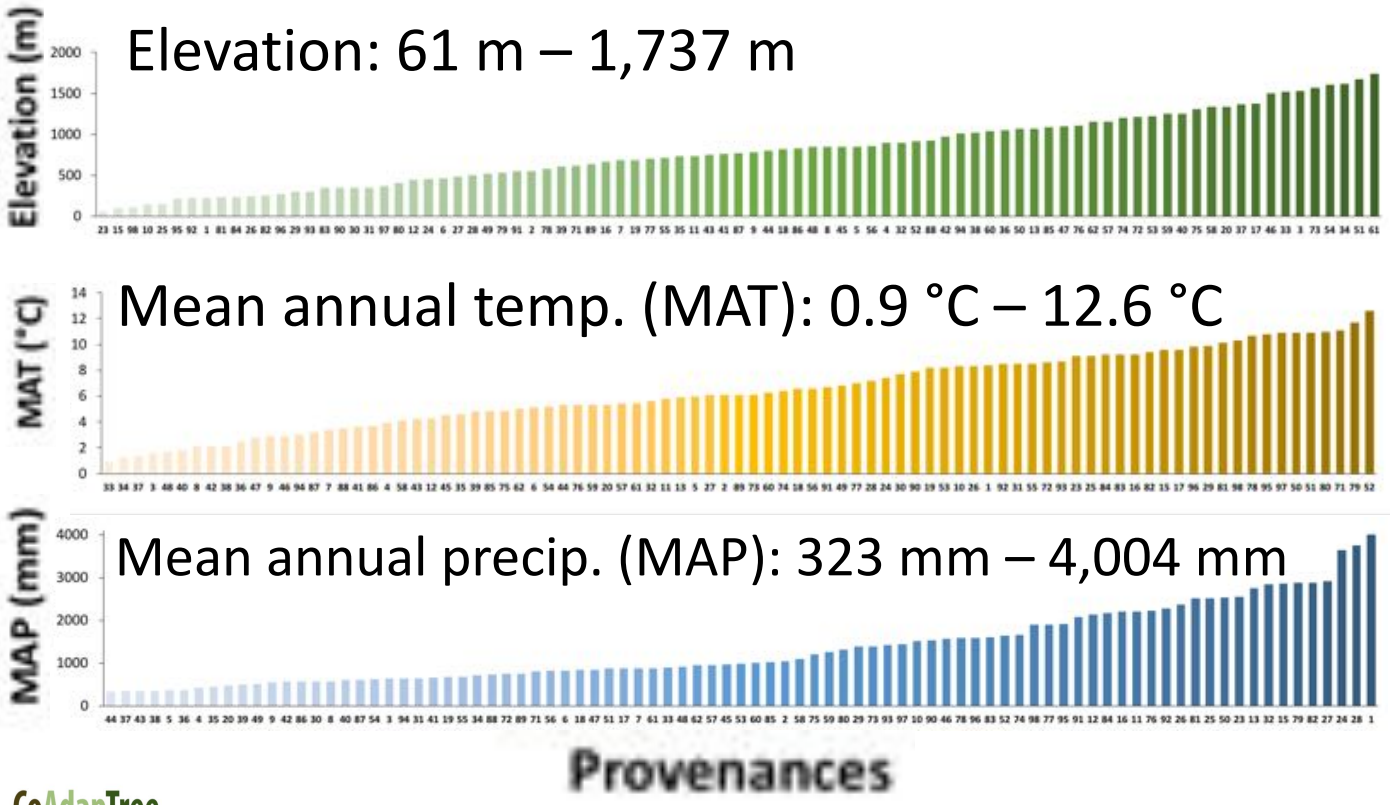
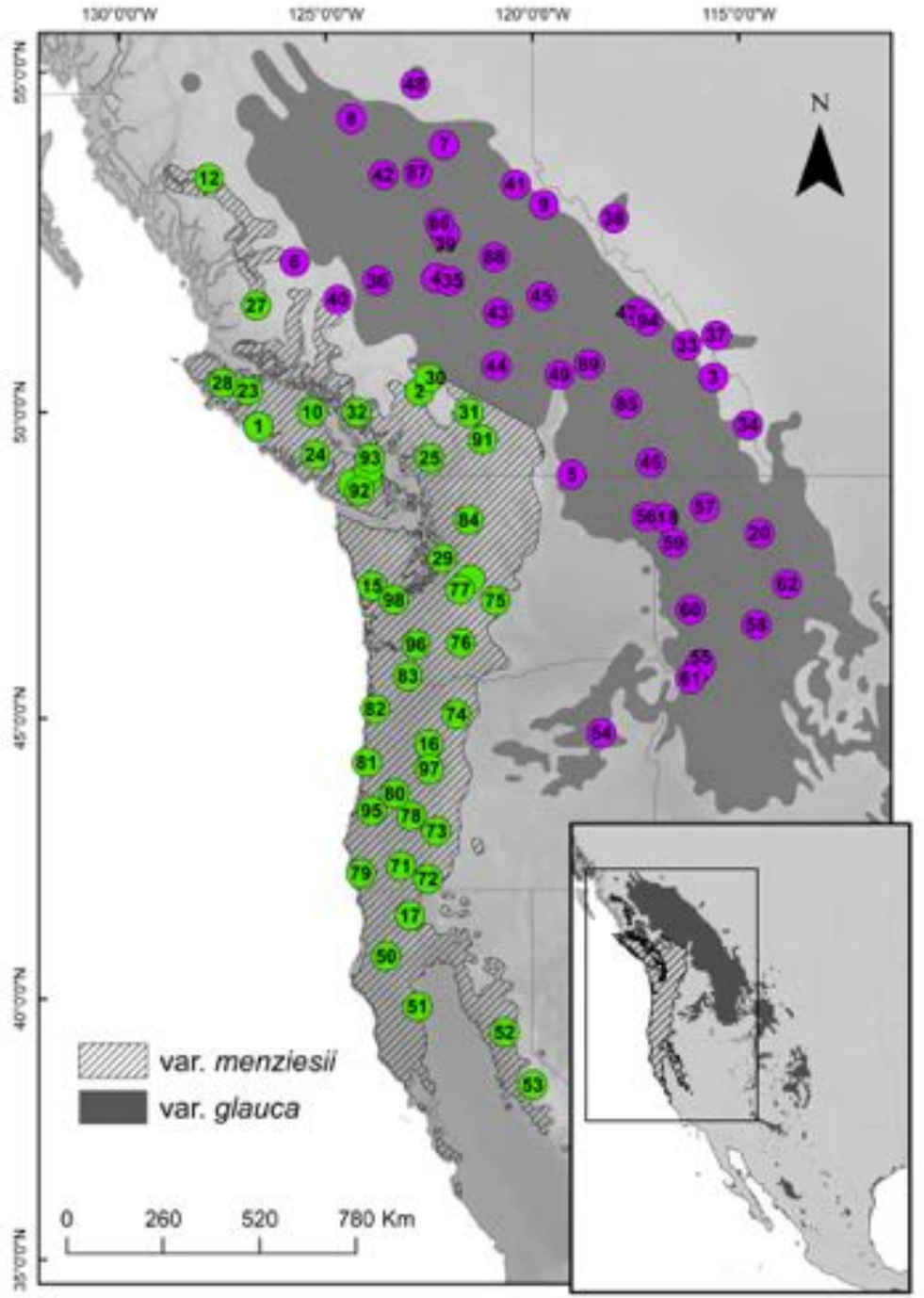
Methods Sampling

- **87 provenances:**
- **45 *Pseudotsuga menziesii* var. *menziesii*** (8 from orchards)
- **42 *Pseudotsuga menziesii* var. *glauca*** (6 from orchards)





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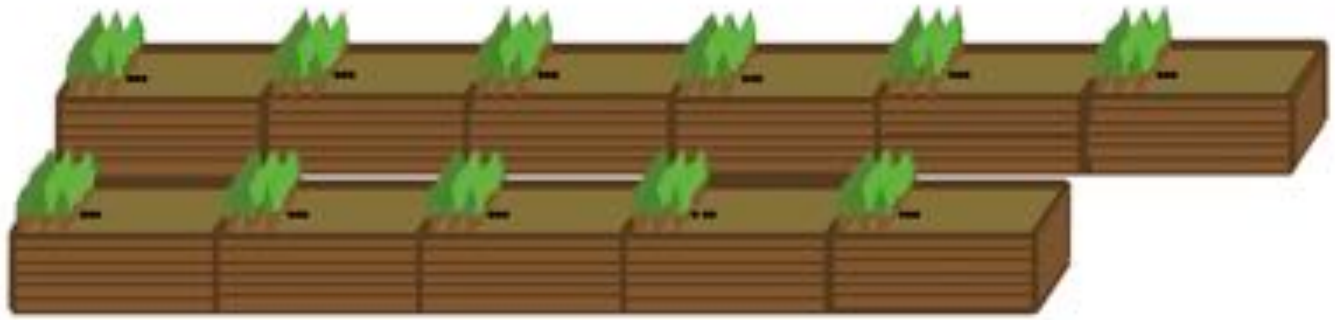
Cold-hardiness

- 1 experiment

Drought-hardiness

- 2 experiments

Cold-hardiness Totem Field (UBC – Vancouver)



- 87 seedlots: 73 natural + 14 sel.
- 11 blocks
- 2,640 seedlings

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Cold hardiness - Phenotyping

- Growth: height
- Phenology
- Fall cold injury: artificial freeze testing with electrical conductivity meters
- Shoot biomass

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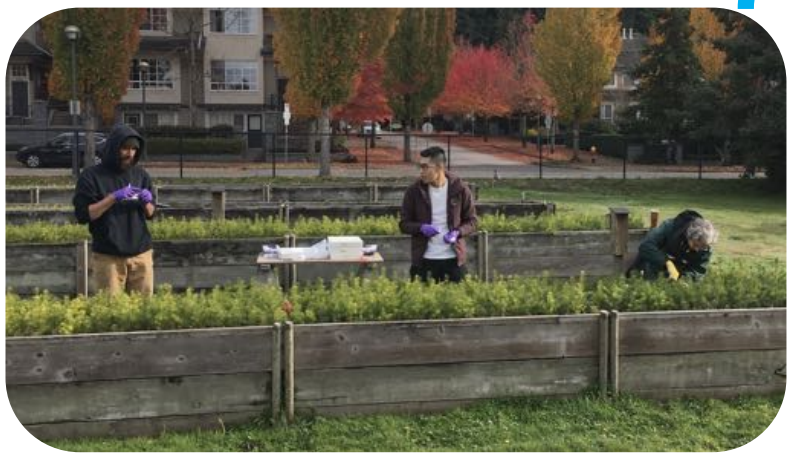
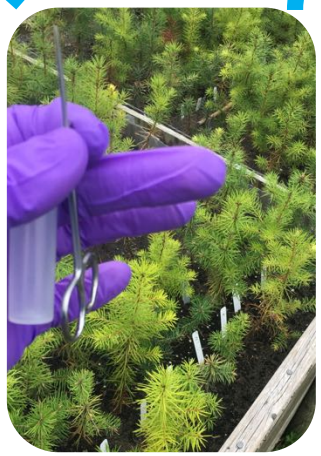
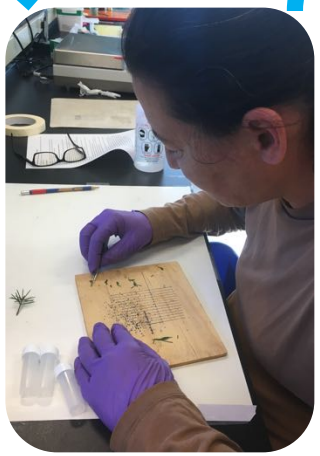
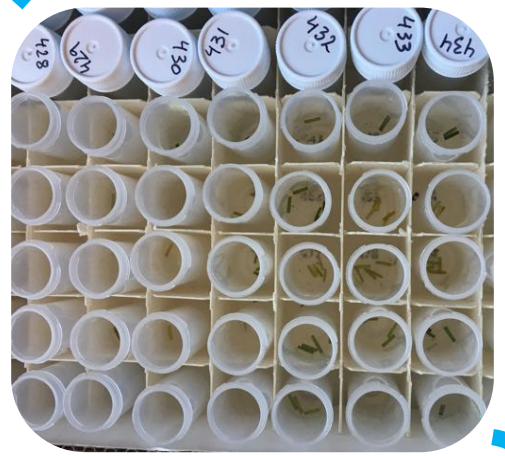
Cold injury testing

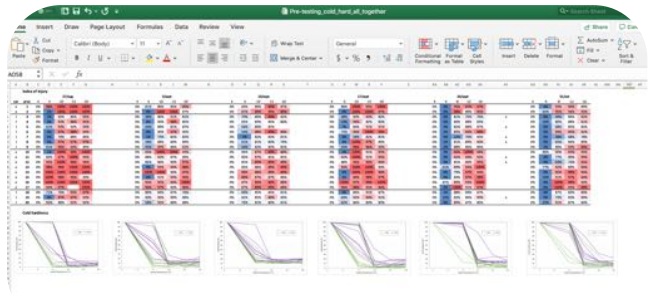
Electrolyte leakage











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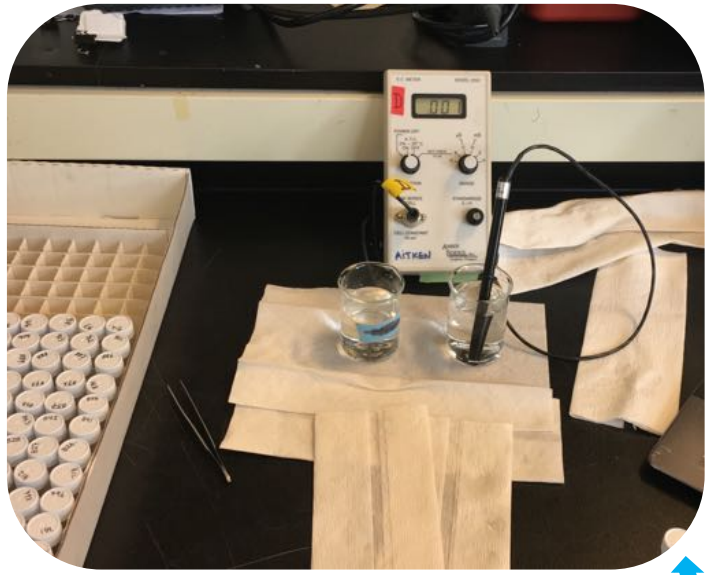

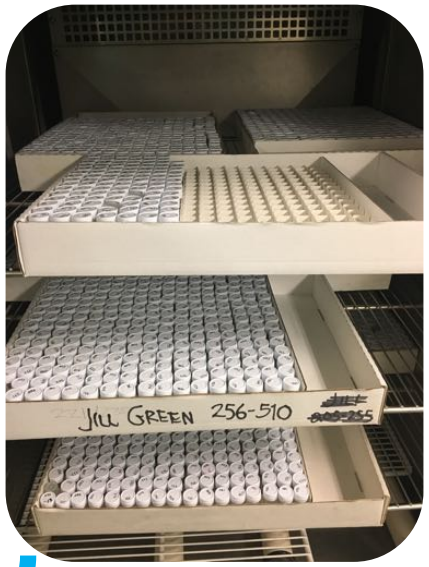

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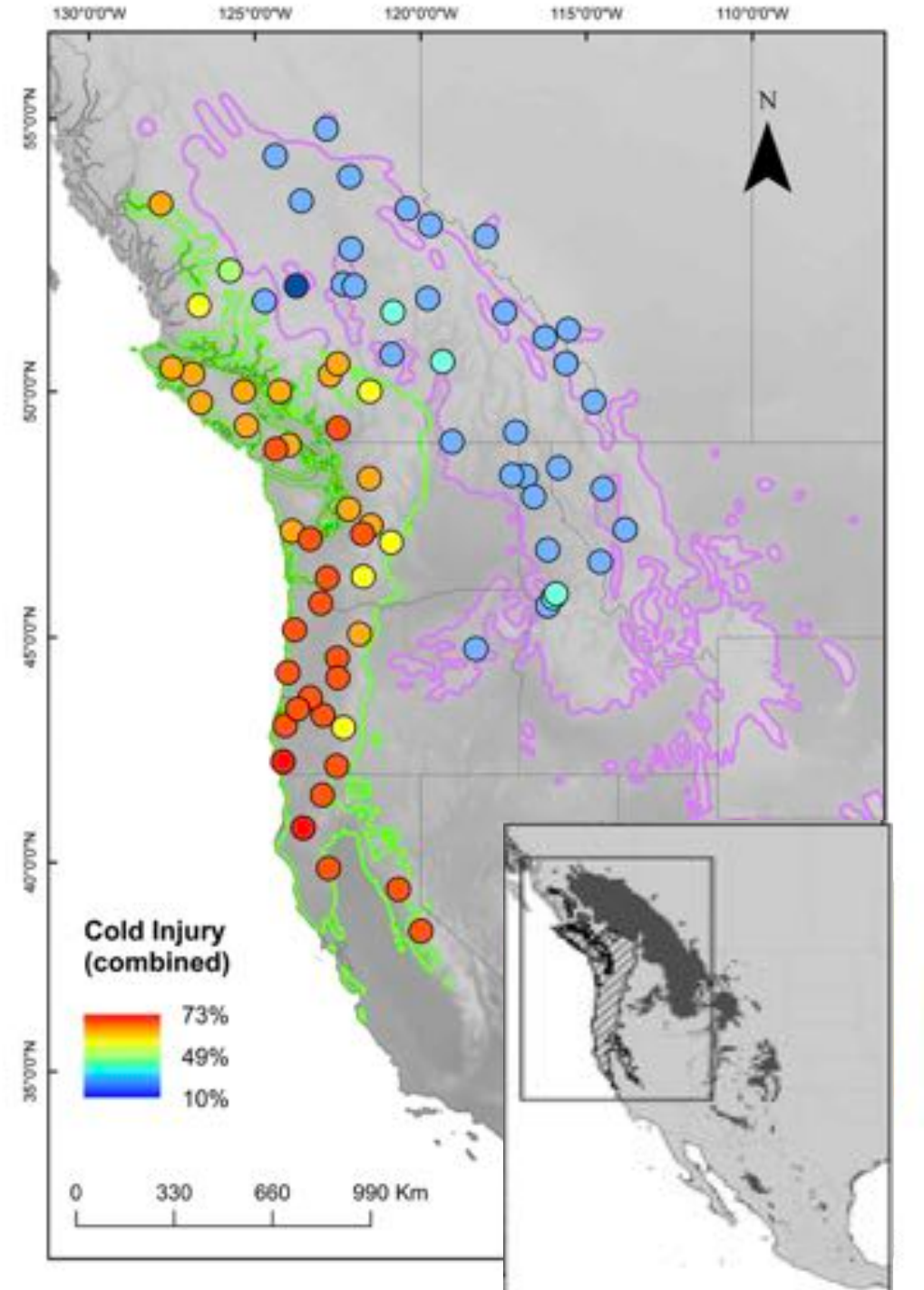
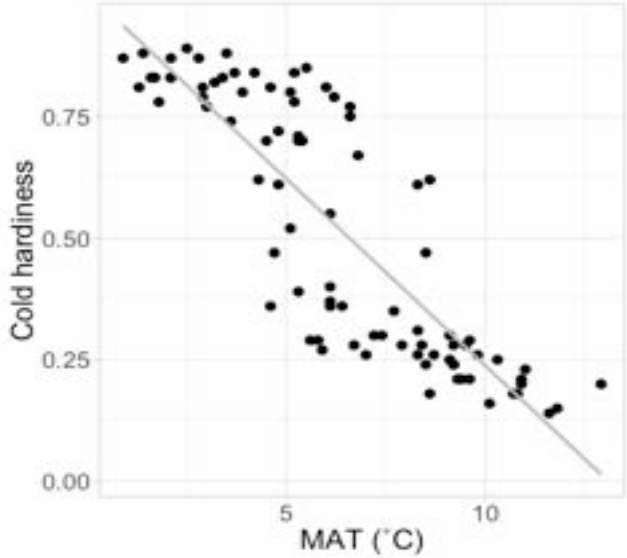
Cold injury:
all populations

Experiment

Source of Variance	Cold Injury
Variety	87%
Provenance	4%
Block	0%
Residual	8%
Vpop (populations)	33%
Vpop (Varieties)	91%





Combined temperatures

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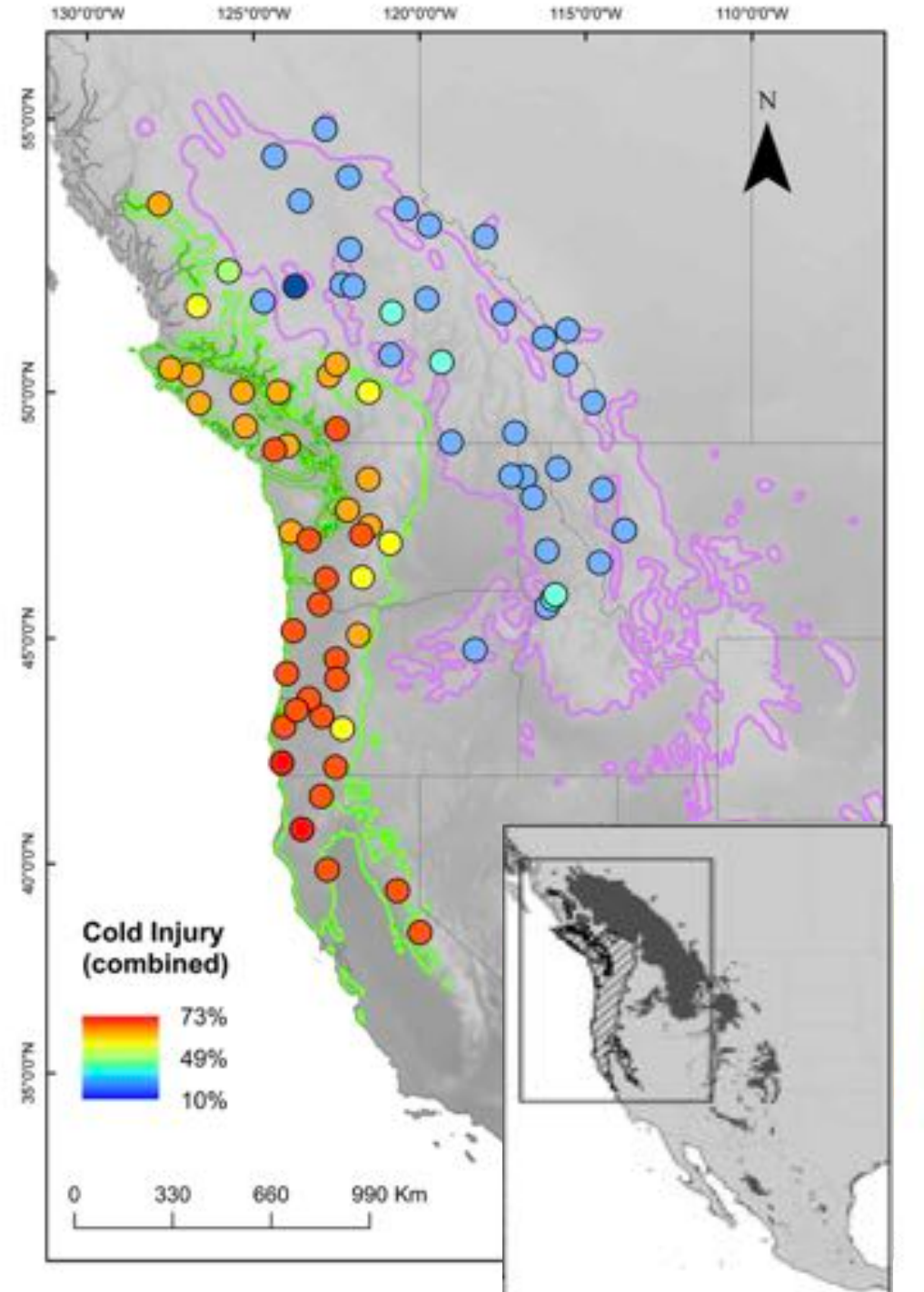

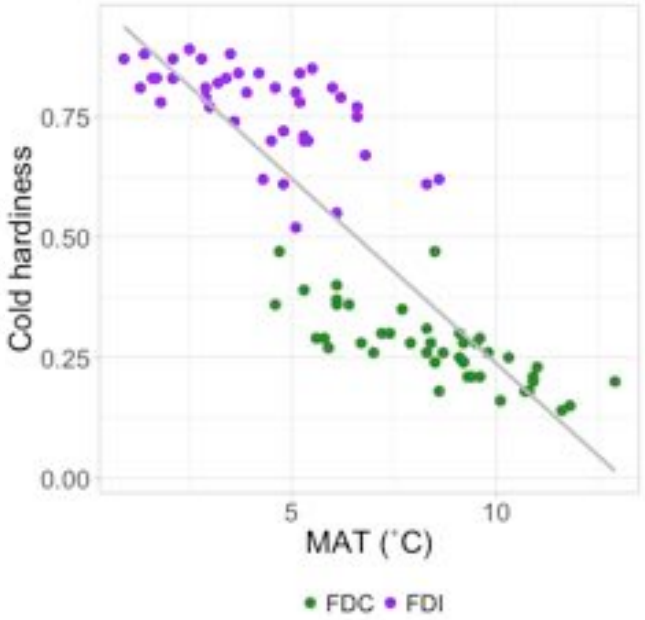

Combined temperatures

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Cold injury: all populations

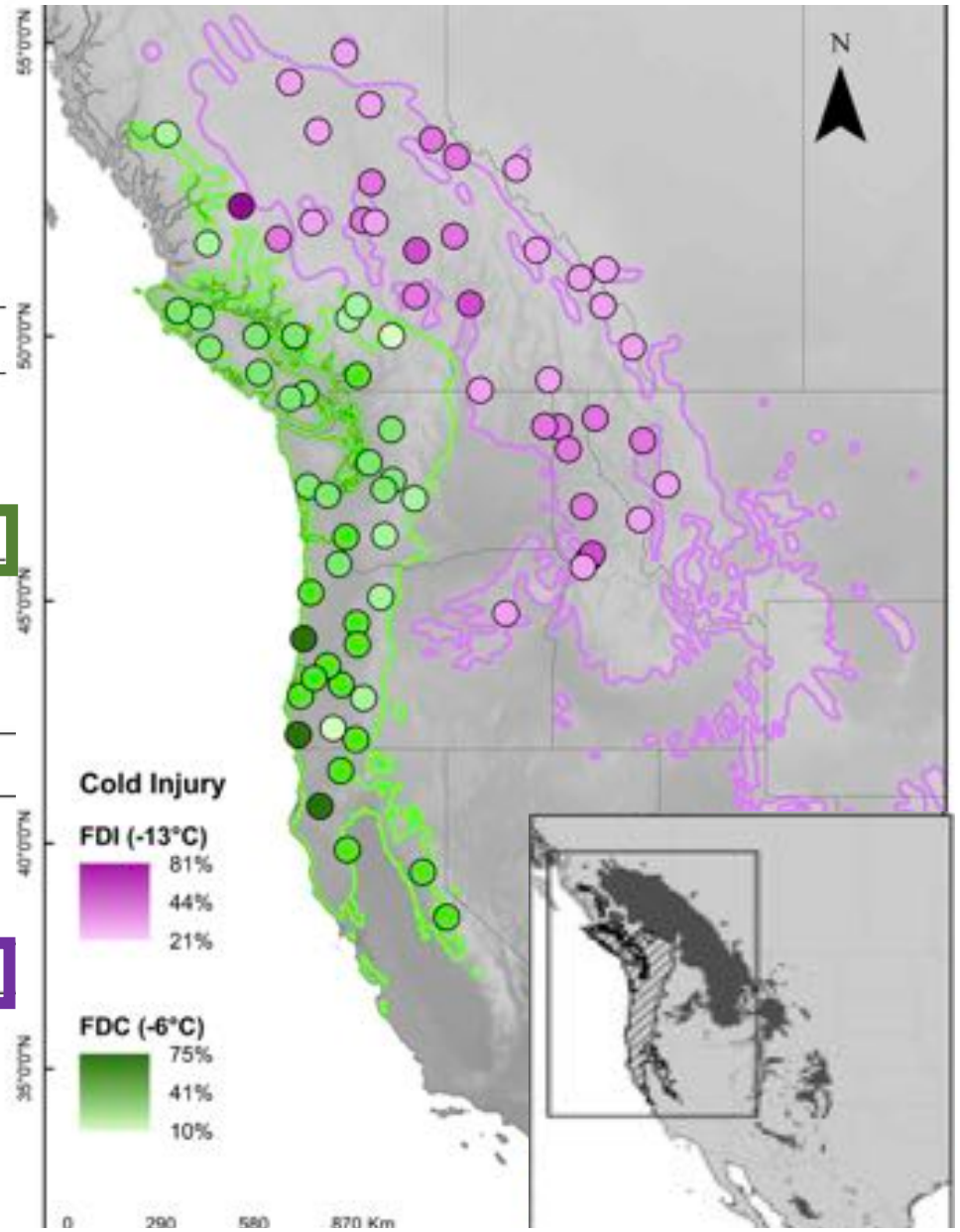
Clear differences between varieties

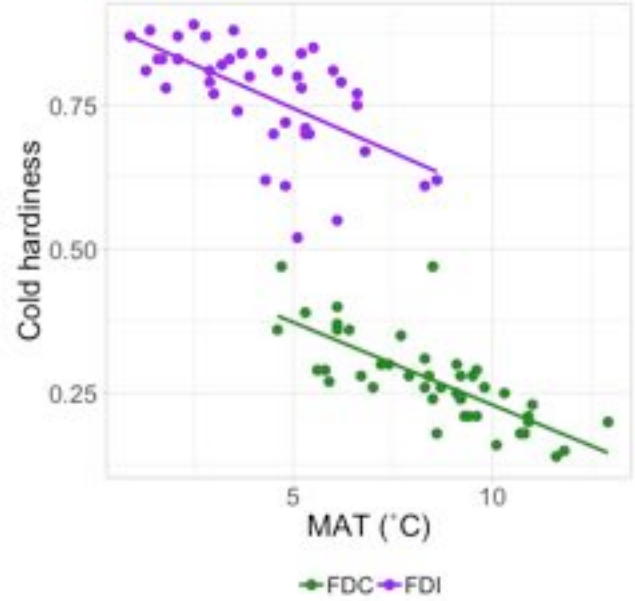
Fdc

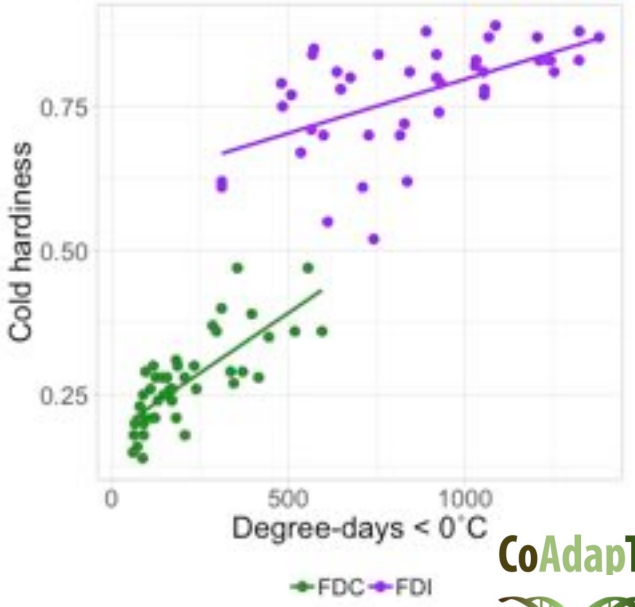
Source of Variance	Cold Injury
Provenance	29%
Block	1%
Residual	70%
Vpop	29%

Fdi

Source of Variance	Cold Injury
Provenance	36%
Block	4%
Residual	60%
Vpop	38%







Clear differentiation among populations

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Drought hardiness

Greenhouse (Department of Botany – UBC)

- 87 seedlots: 73 natural + 14 sel.
- 4-18 seedlings from each provenance
- 1,440 seedlings

Drought treatment (Dry)

Control (Wet)

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Methods

Chlorophyll fluorescence (Fv/Fm) measurements - Dark adapted

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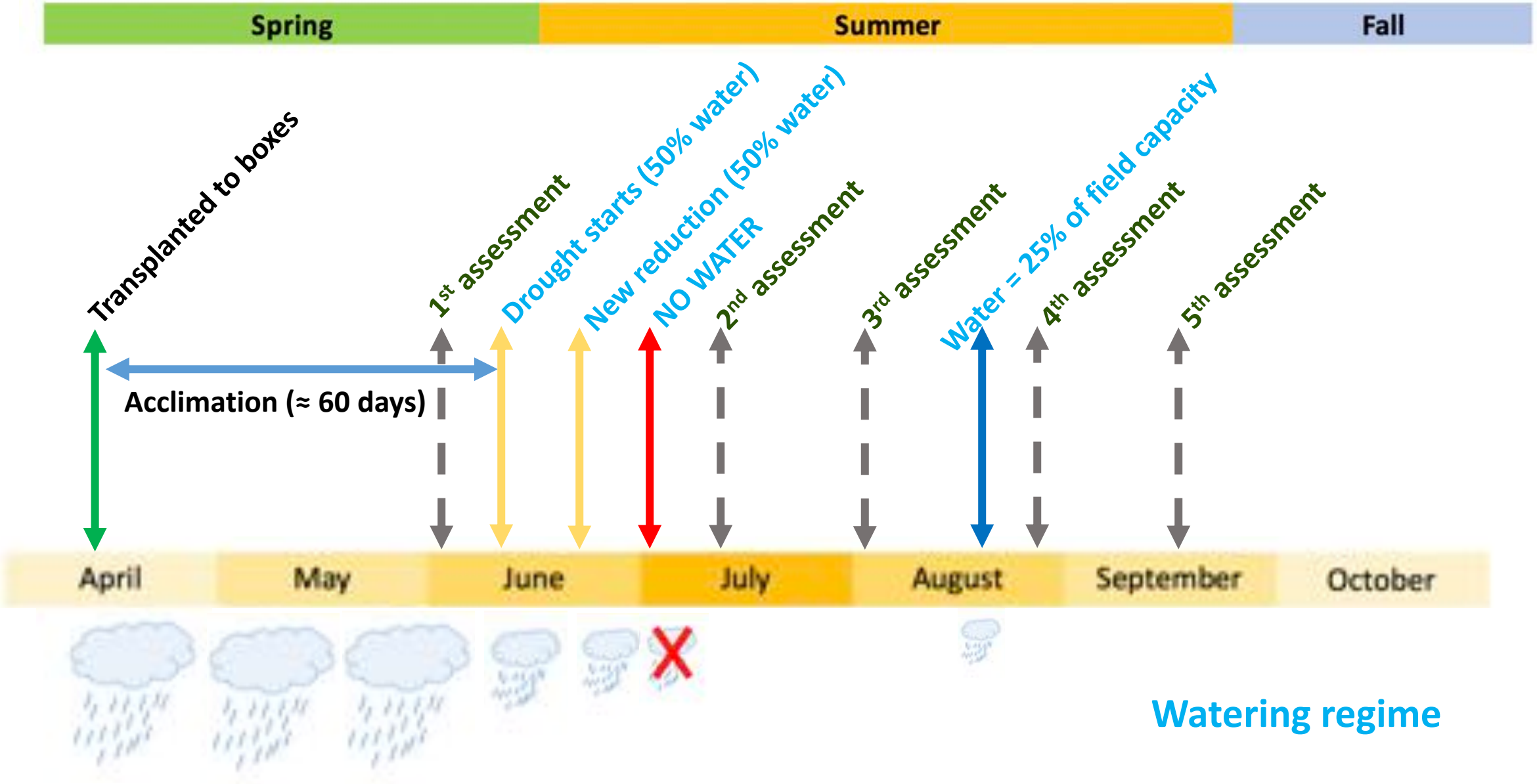
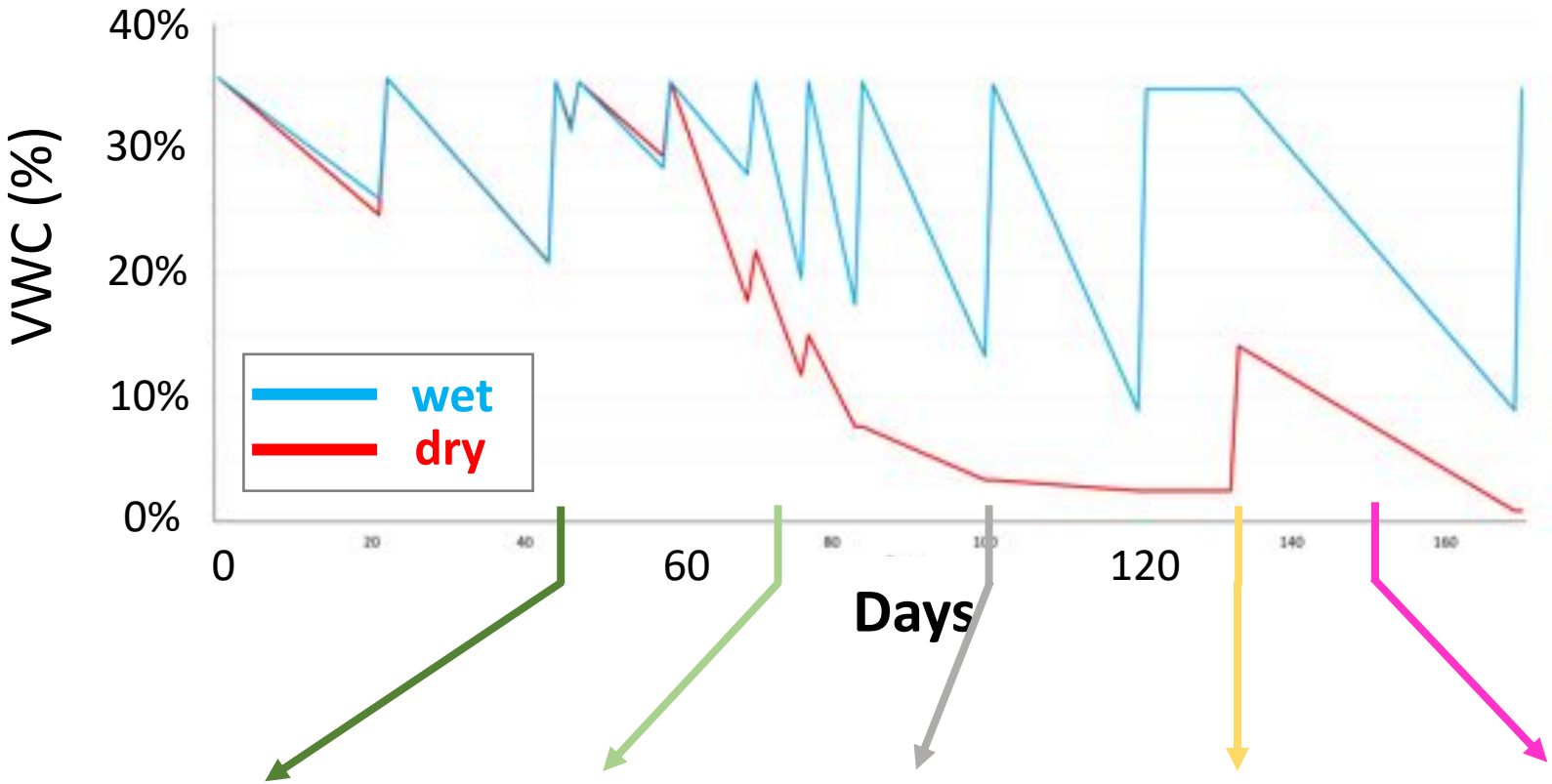


Soil water content



Experiment over time

Drought hardiness Analysis (Fv/Fm)

- **Spatial autocorrelation correction (ASReml-R)**

- $Fv/Fm_{(corrected)}$ = Fv/Fm – spatial effect

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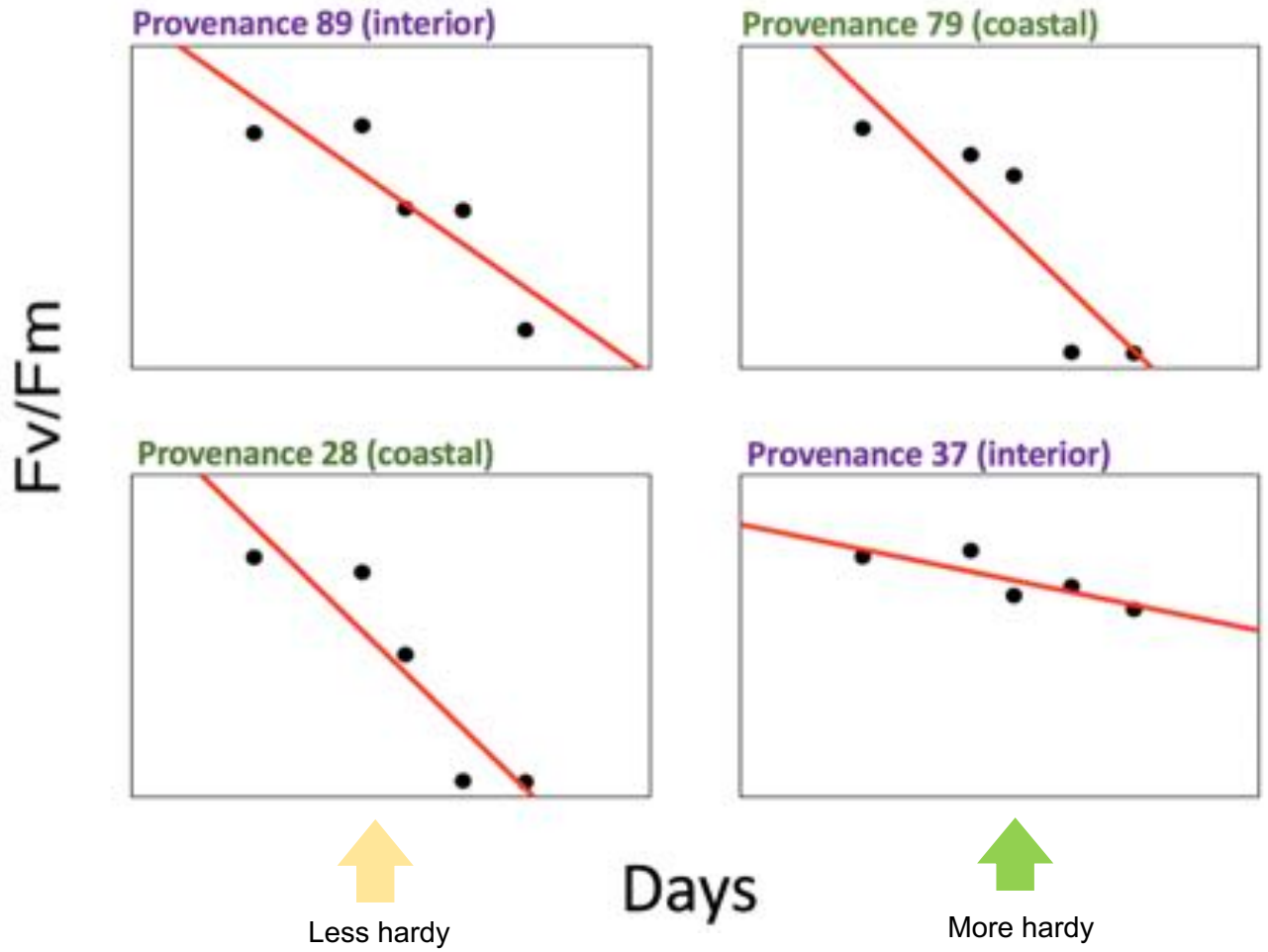
Drought hardiness Analysis (Fv/Fm)

- **Corrected Fv/Fm slopes as a proxy for drought-hardiness (simple linear regression)**



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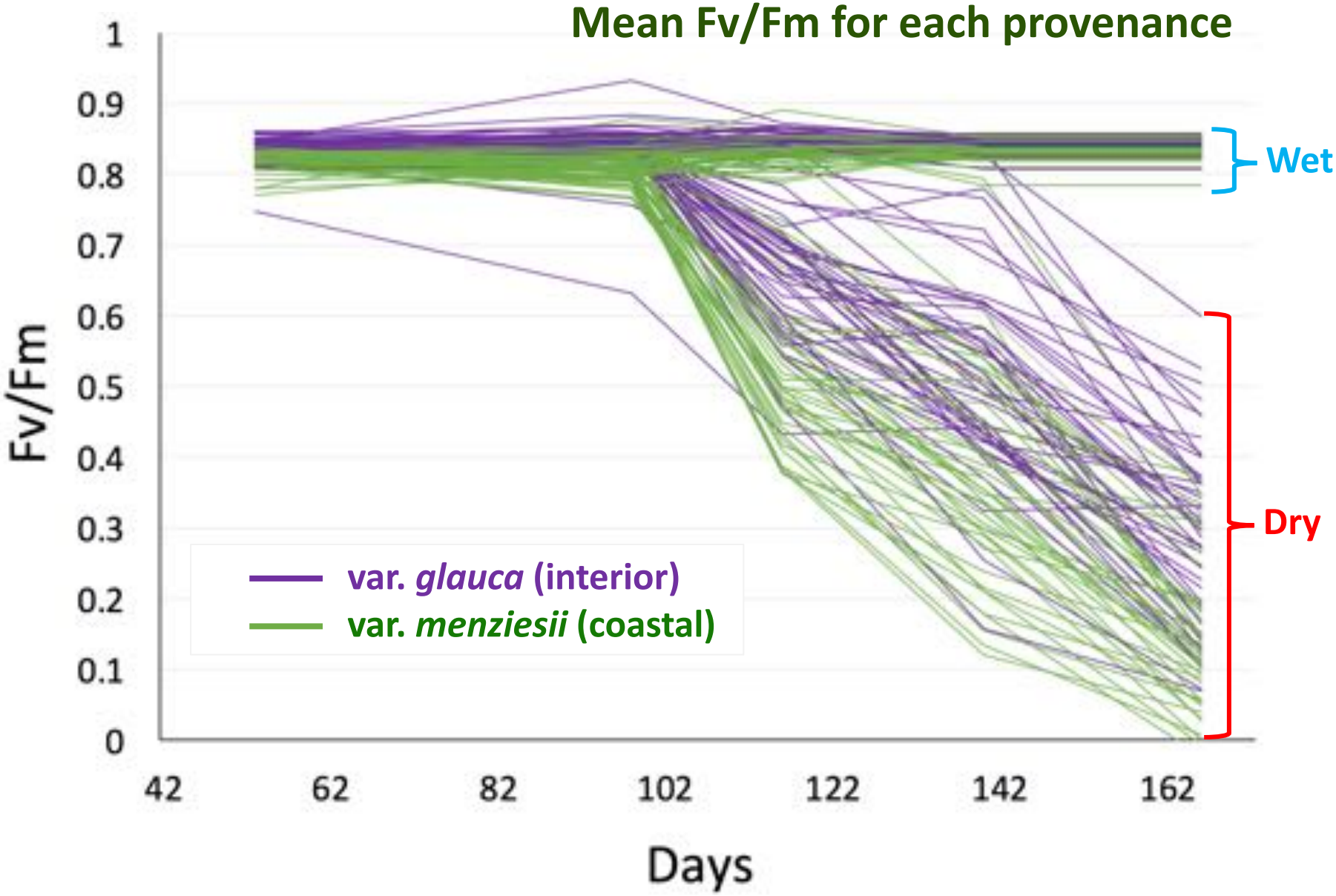
Drought hardiness Results



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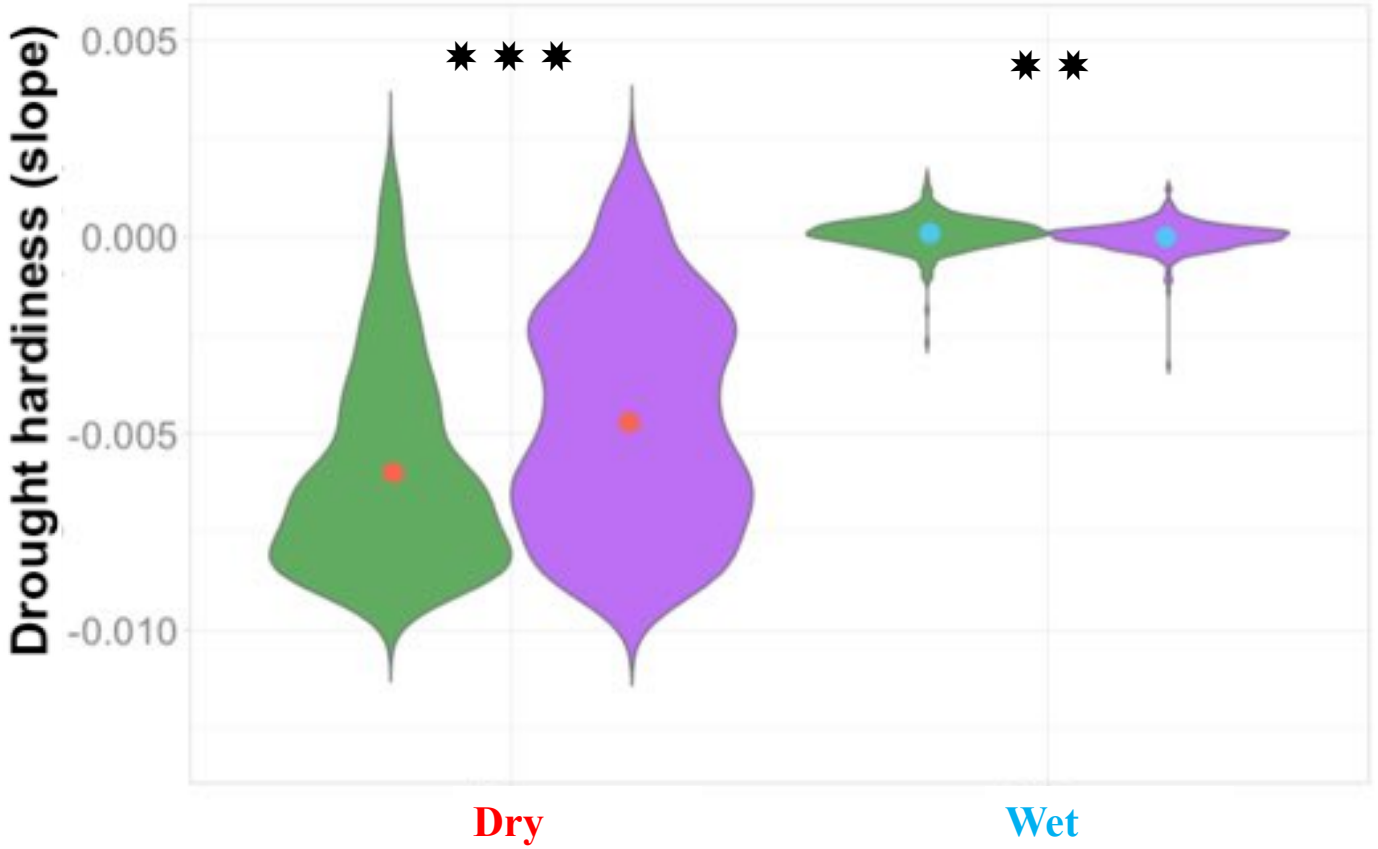
Drought hardiness Results

Clear differences between varieties



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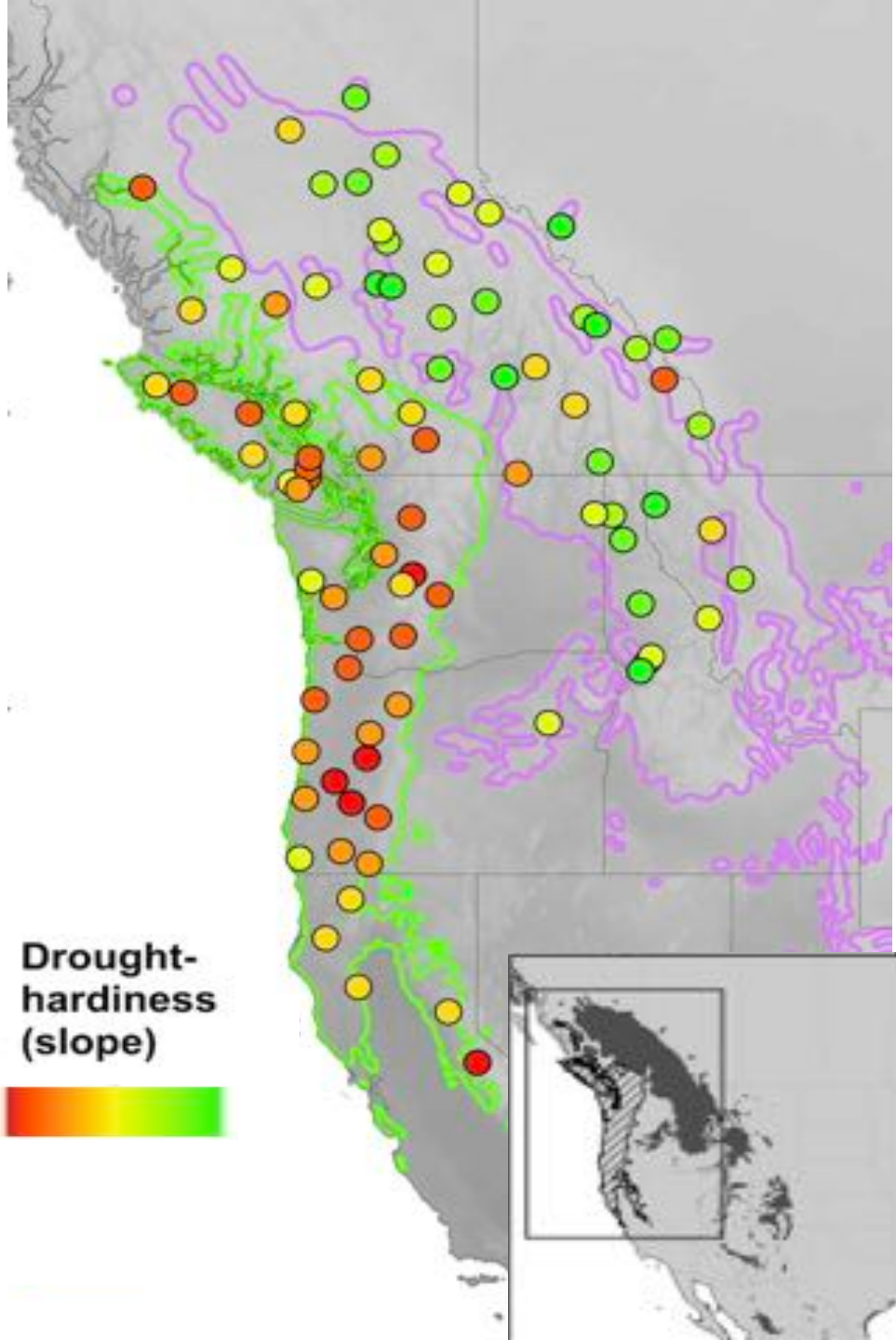
Drought hardiness Results

Distribution of drought-hardiness variation (varieties together)

Experiment

Source of Variance	Drought hardiness
Variety	10%
Provenance	4%
Block	6%
Residual	80%
Vpop (populations)	4%
Vpop (Varieties)	11%



Drought hardiness Results

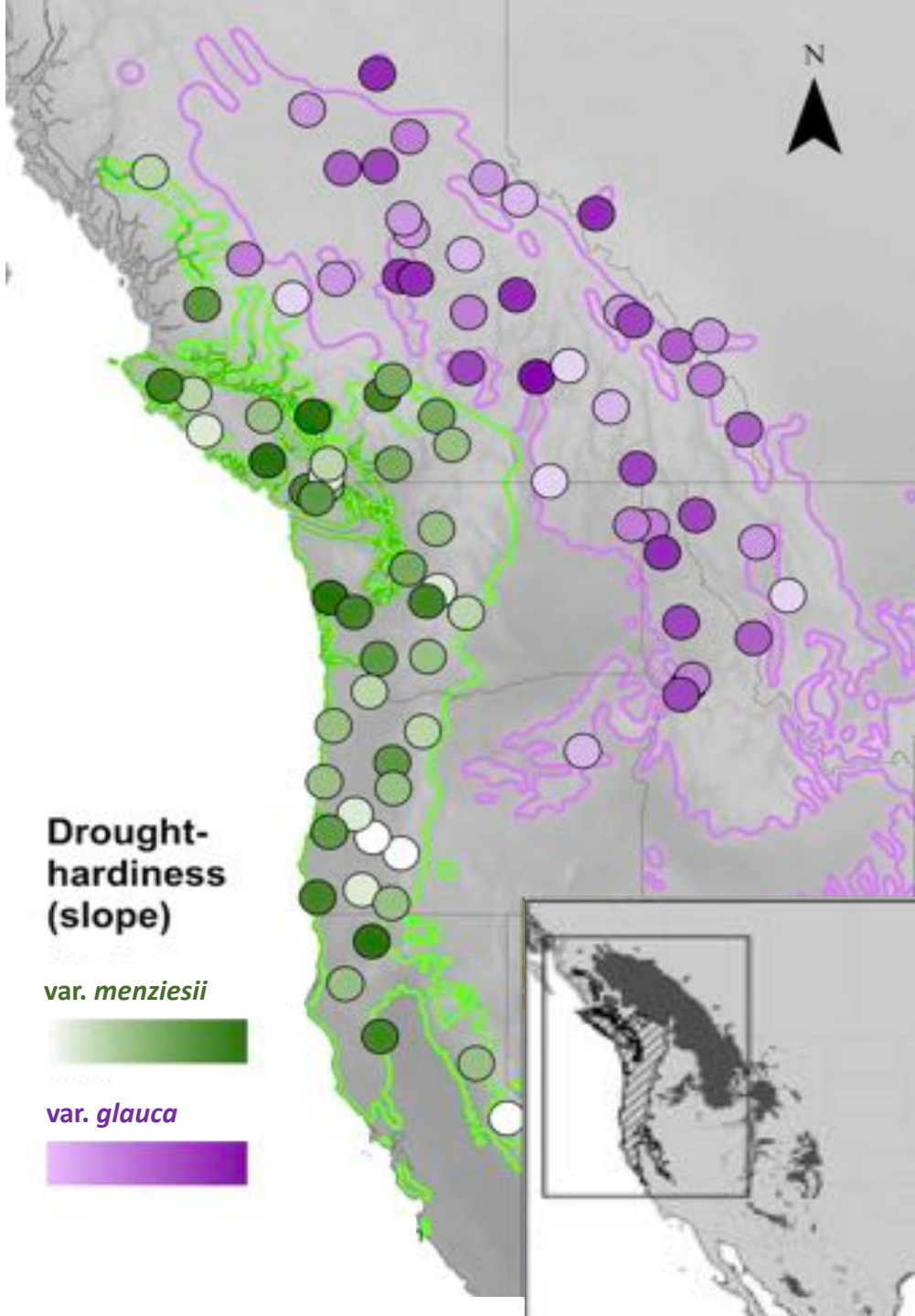
Distribution of drought-hardiness variation (varieties separated)

Fdc

Source of Variance	Drought hardiness
Provenance	1%
Block	2%
Residual	97%
Vpop	1%

Fdi

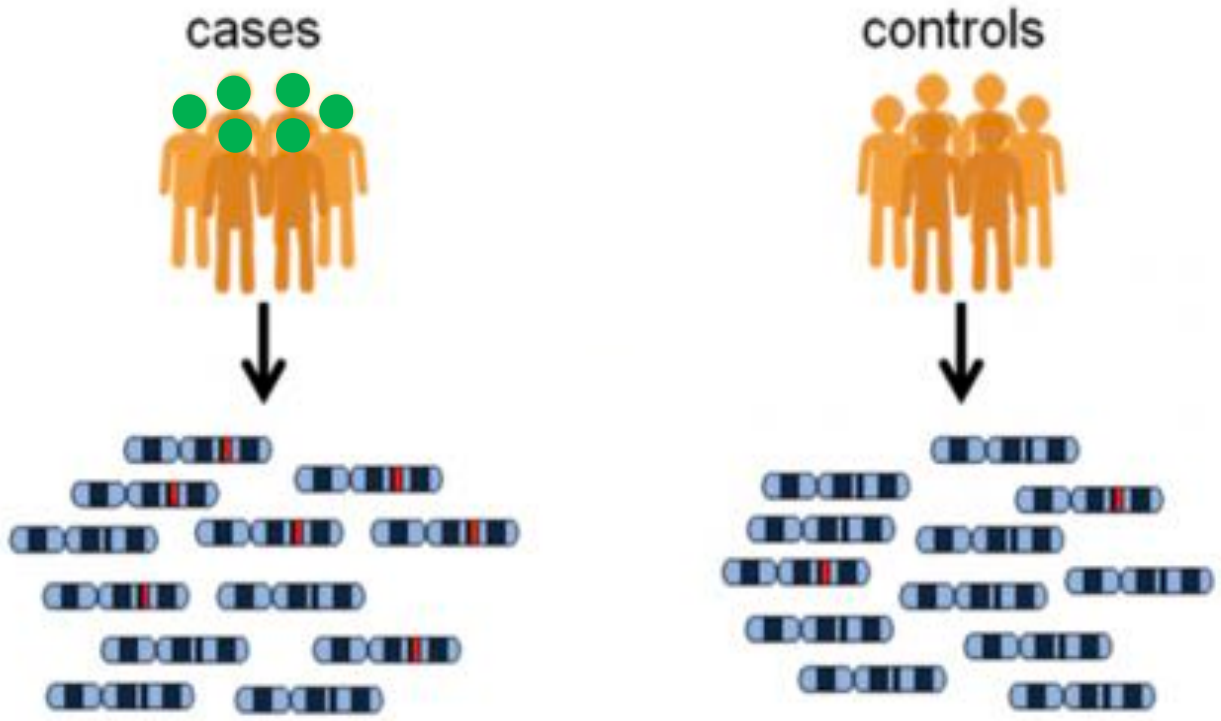
Source of Variance	Drought hardiness
Provenance	6%
Block	10%
Residual	83%
Vpop	7%



Case-control GWAS (phenotype x allele frequencies)

Phenotype

Genotype



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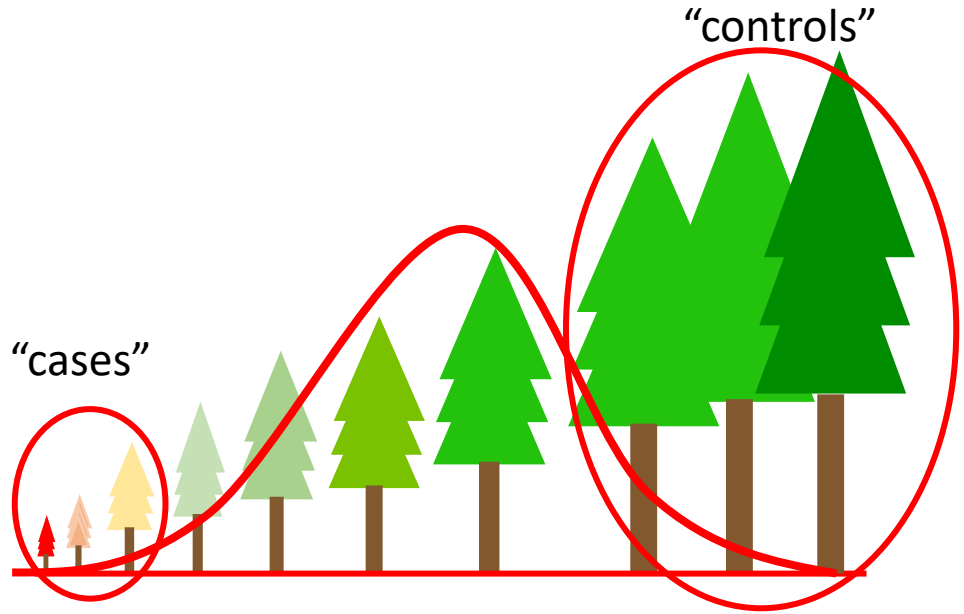
Case-control GWAS (phenotype x allele frequencies)

Phenotype



Genotype

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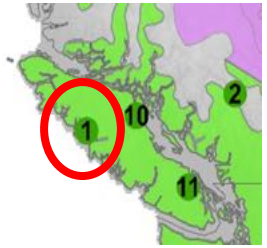
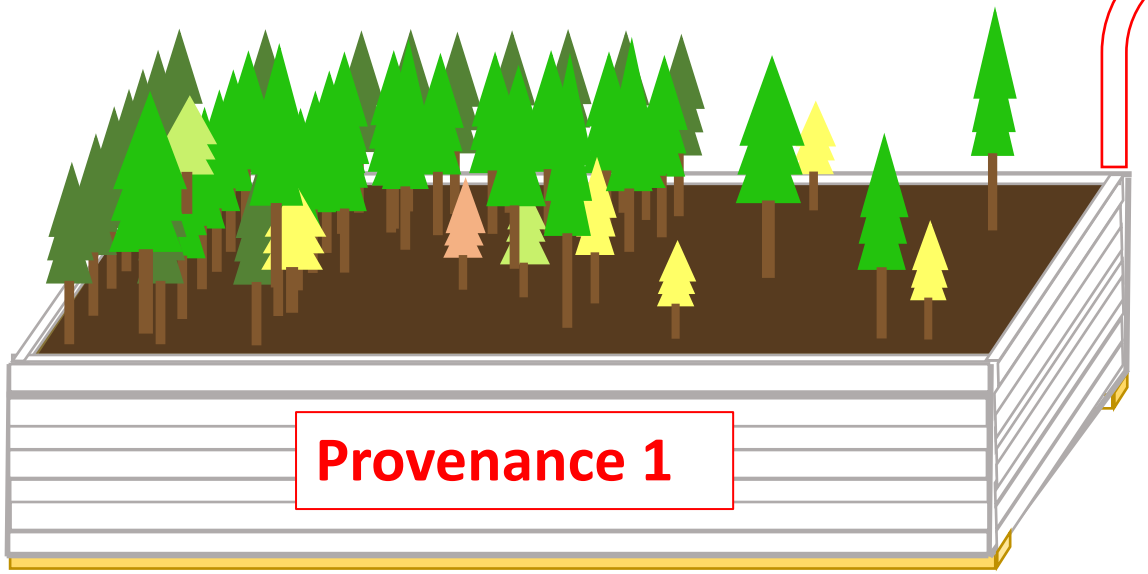
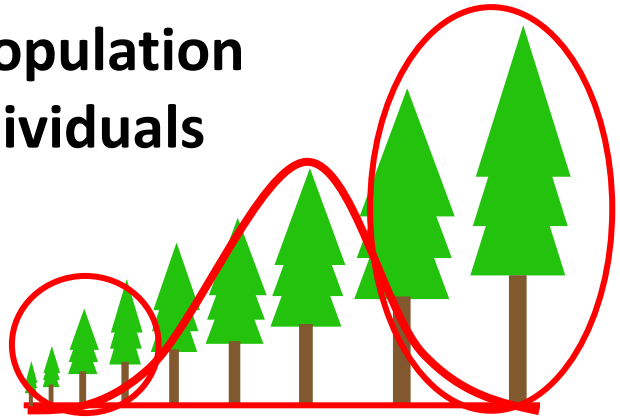
Case-control GWAS





Phenotyping

2 pools/ population
= 400 individuals



10 **Case-control** 10

≈ 50 Mb targeted sequence capture (pooled groups within populations)

GWAS

Candidate Genes detection (drought tolerance)

Patterns of adaptive allele distribution

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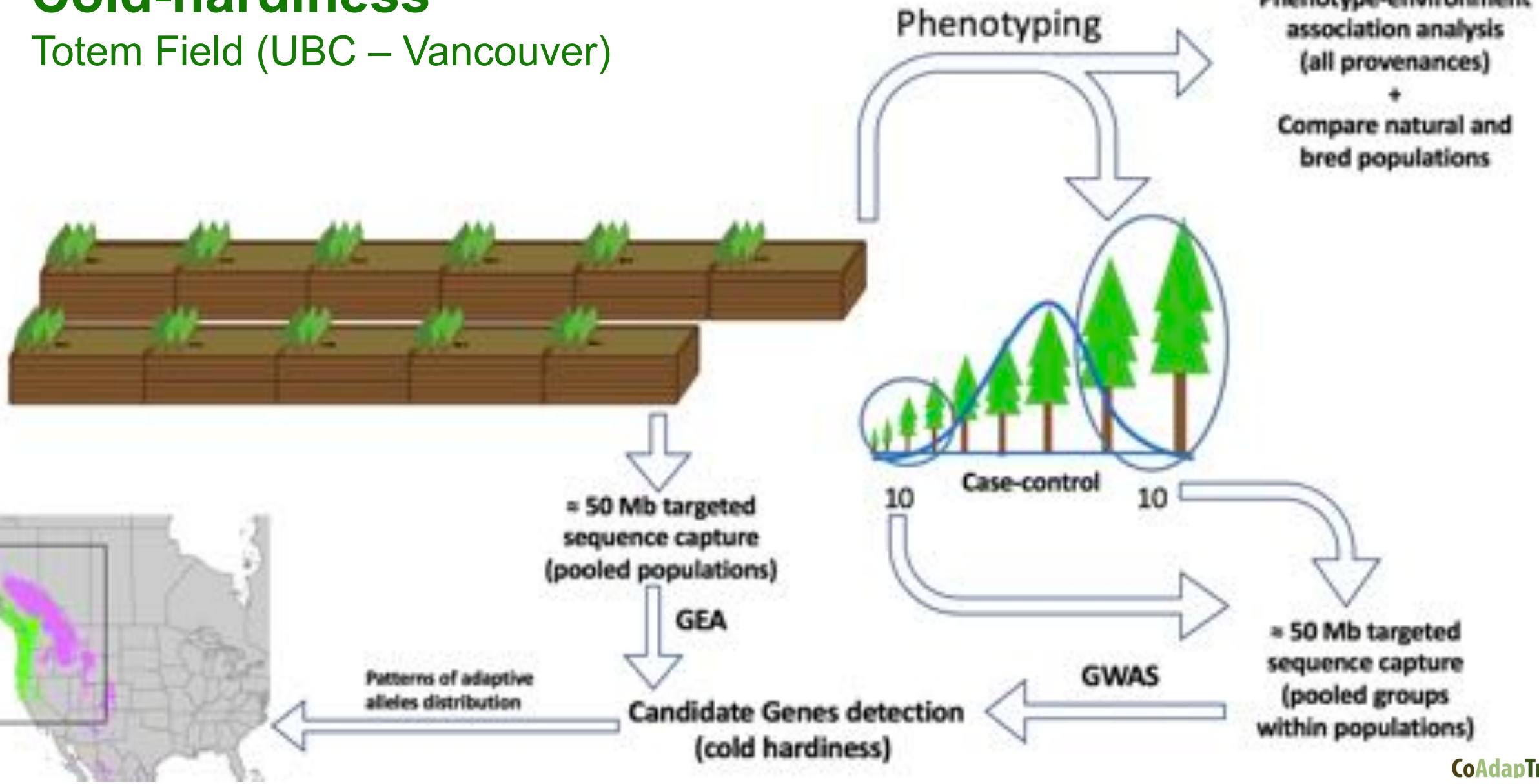
Cold-hardiness

Totem Field (UBC – Vancouver)



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Take-away and next steps

- **Differences between the two varieties were observed for cold and drought hardiness.**
- **Local adaptation to drought in the seedling stage is weak within var. *glauca*, but it is almost absent for var. *menziesii*.**
- **Local adaptation to frost in the fall is strong within both varieties, but stronger in the interior (variation among populations)**
- **Substantial variation within populations in both varieties suggests great genetic variation, micro-environmental factors and plasticity might also play a role in Douglas-fir drought tolerance dynamics.**

Take-away and next steps

- **Analysis of the other measured traits and comparisons between natural and selective-bred populations underway.**

- **GWAS to detect candidate genes associated with the observed patterns in drought tolerance and cold hardiness. (50 ~ Mbp)**

- **Results from this study, which is part of CoAdapTree, will be used to inform CBST for reforestation.**

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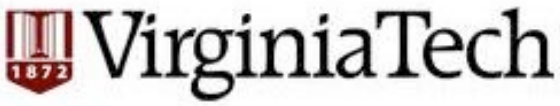
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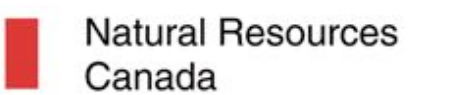
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