SELECTING DROUGHT TOLERANT TREES USING TREE RING ANALYSES

Resilient Forests (RES-FOR) genomic selection project

Jaime Sebastian Azcona

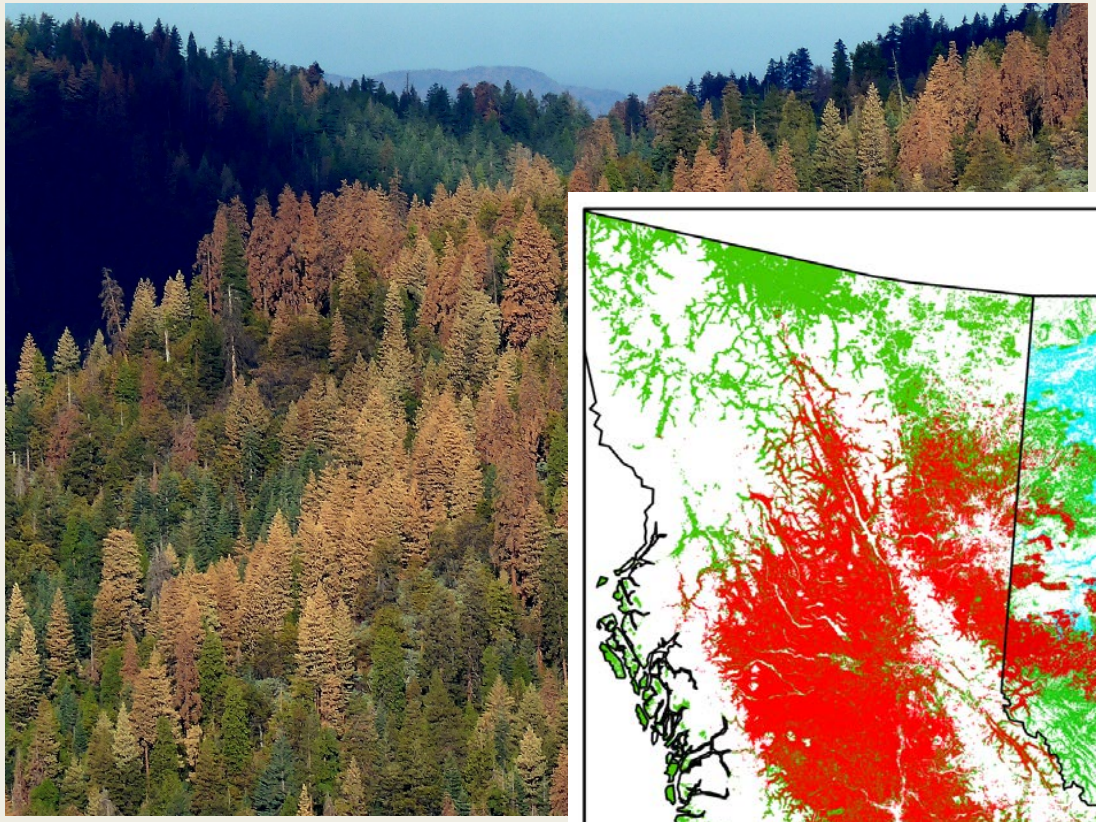
January 22nd, 2020

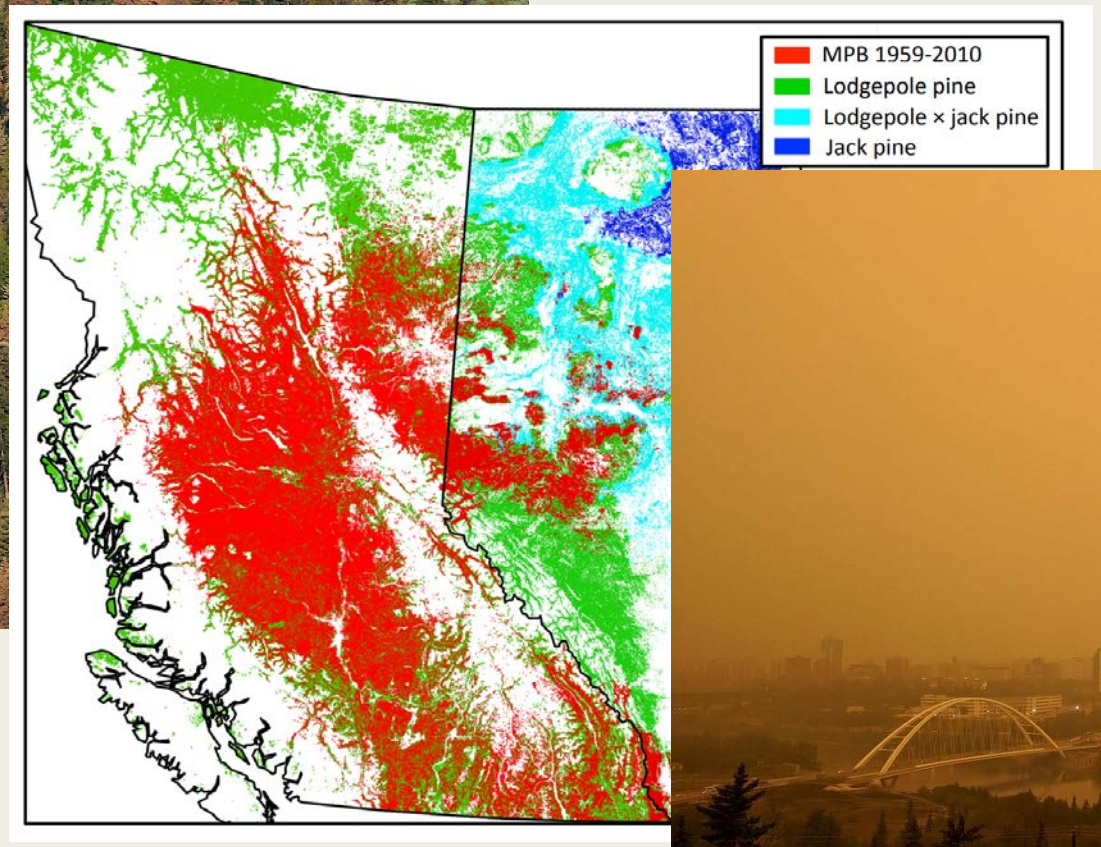
ITAC Extension Meeting

The RES-FOR Team – Nov. 2019 meeting

Team lead & co-leads: Barb Thomas, Nadir Erbilgin & Yousry El-Kassaby

Climate change threats





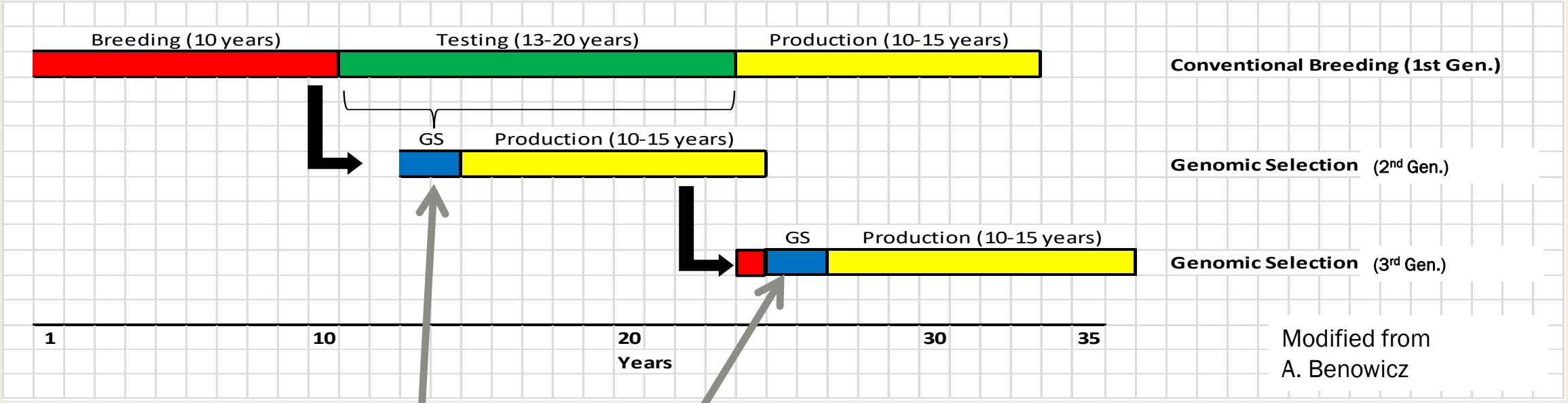
The RES-FOR Project

- Integrating traditional tree improvement with new ***genomics based selection***
- Introducing novel selection traits for assessing responses to biotic (pests) and abiotic (drought) stresses
  - *E.g.: terpenes, metabolomics, ecophysiology*
- Outreach, collaboration, policy, economics & understanding social acceptance of this emerging application in forest tree breeding

This is the moment to do it!

- ✓ *Significant reductions in the cost of genotyping*
  - ✓ ~$50/sample
- ✓ *Programs in Alberta about to move to the 2nd generation*
  - ✓ can therefore put theory into practice quickly
- ✓ *Interdisciplinary collaboration making it possible*
  - ✓ AB Govt, industry, Universities (UofA, UBC, Calgary, Oklahoma), social scientists, genomics & quantitative geneticists, entomologists, climate modelers etc.

Genomic selection:

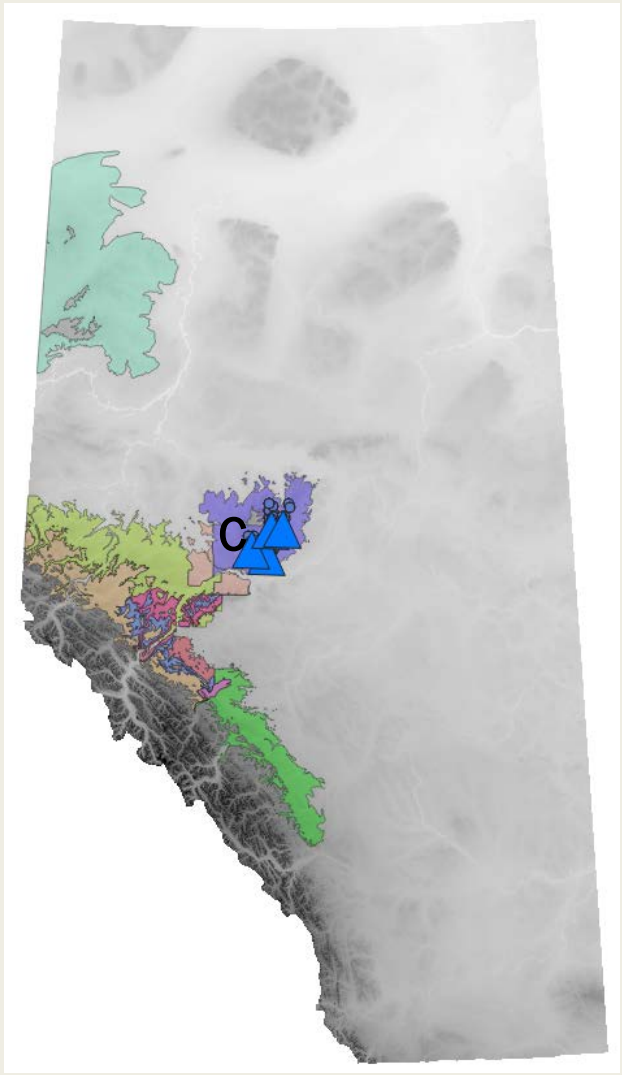


Replacing phenotyping with genotyping

- Shorten the breeding cycles
- Increase the precision of selection
- ⇧gain in each cycle

Where is RES-FOR?

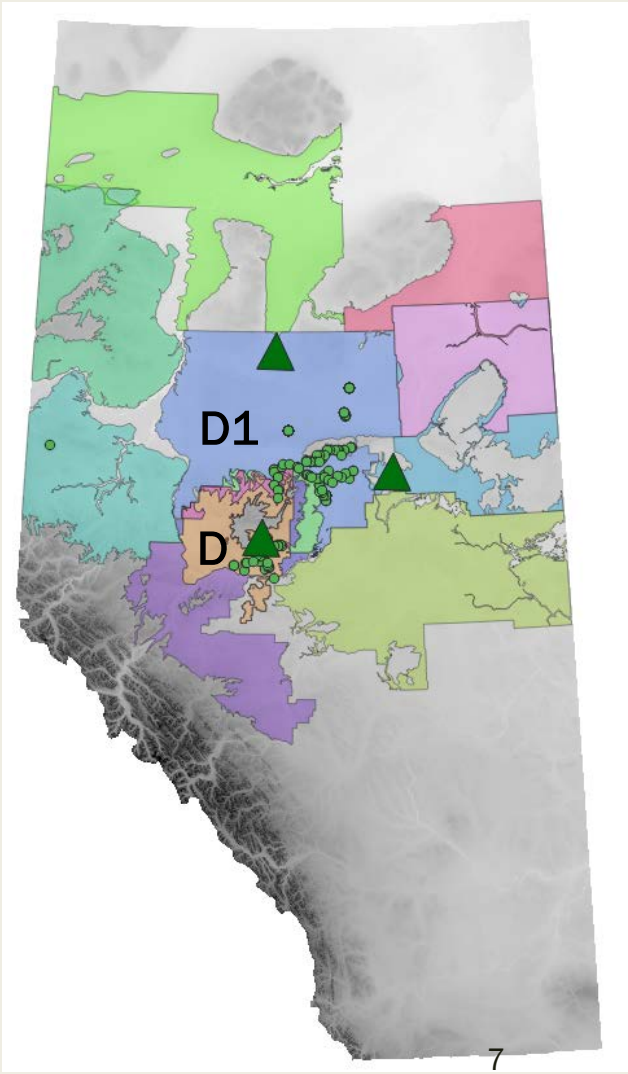
Lodgepole Pine – Region C



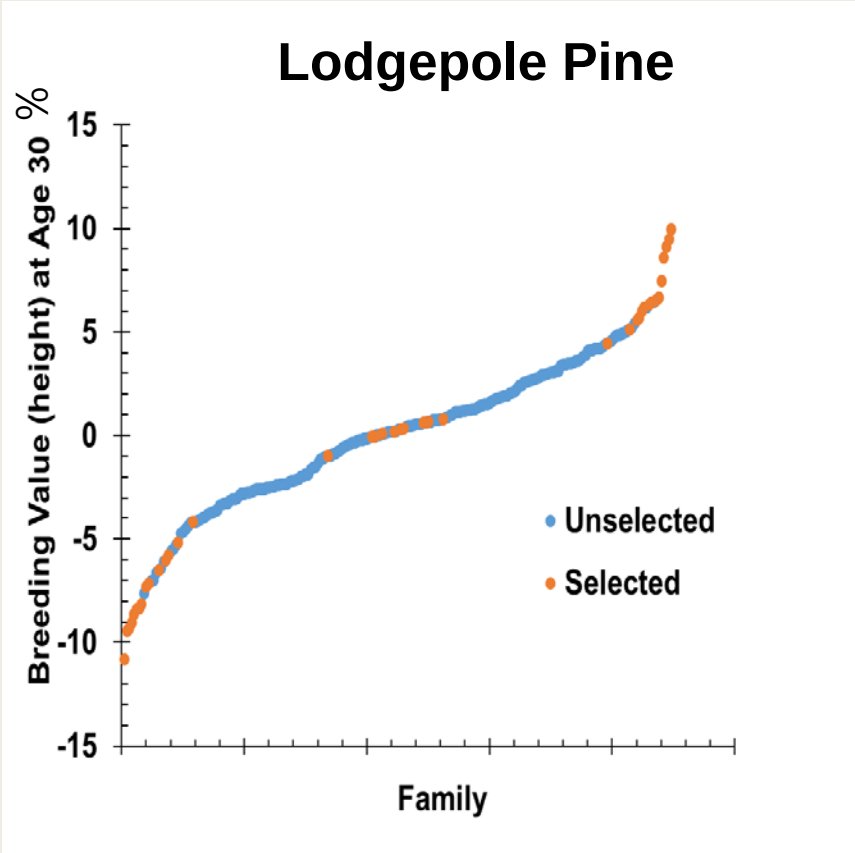
Programs have:

- ✓ 100+ families/species
- ✓ Existing breeding values for height
- ✓ 3+ progeny tests
- ✓ 30+ years of age
- ✓ Seed available for greenhouse trials
- ✓ Programs ready for genomic selection

White Spruce – Regions D - D1

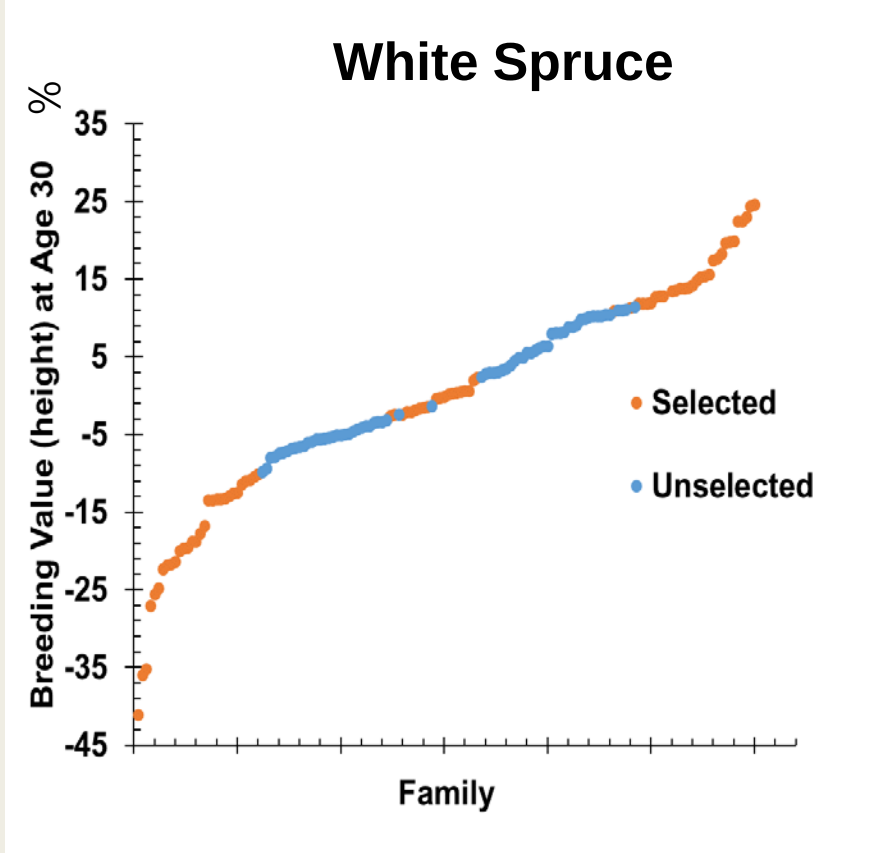


Seedlot Selections



CPP Region C: 40 Families
15 Families with high Breeding Value
10 Families with medium Breeding Value
15 Families with low Breeding Value

40F x 10 trees x 4 sites = 1600 trees



CPP Region D & D1: 80 Families
30 Families with high Breeding Value
20 Families with medium Breeding Value
30 Families with low Breeding Value

80F x 8 trees x 2 sites + 80F x 4 trees x 1 site = 1600 trees

Traits studied

		Field		Greenhouse	
Measure	Tissue	Pine	Spruce	Pine	Spruce
Gas exchange	Needles	1	2	5	5
13C and total N and C	Needles	1	2	1	1
Specific leaf area	Needles	1	2		
Stomatal density	Needles	1		1	1
Ring width	Wood	4	3		
Wood density/MFA	Wood	4	3		
13C	Wood	1	1		
Height/Diameter	Wood	4	3	1	1
Elemental analysis n=38	Needles	1	3	4	5
Phenolics (n=19)	Needles	1	1		5
Primary metabolites (n=164)	Needles	1	3	5	5
Monoterpenes (n=15)	Phloem	4	1	1	
Monoterpenes (n=11)	Needles		3		1
Resin ducts (n=10yrs)	Wood	1	1	1	1
SNP		4	3	1	1

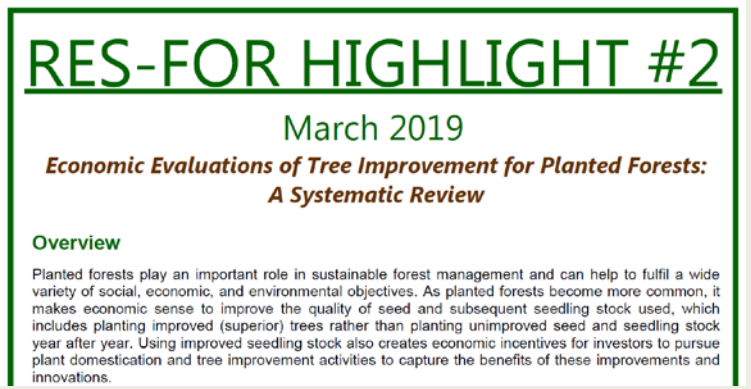
The RES-FOR Social & Economic Approaches

- *Social Science tools*:
  - *Interviews (public, practitioners & researchers)*
  - *Scenario mapping*
  - *Deliverables and education*

- *Economics tools*:
  - *Conjoint study (End-users)*
  - *Optimization analysis (Weyerhaeuser)*
  - *Economic models linked to G&Y*

Examples of deliverables so far…

- ✓ Five publications
- ✓ Four ‘Highlight Sheets’
- ✓ Economic workshop
- ✓ Education resources for grade 6 and 12



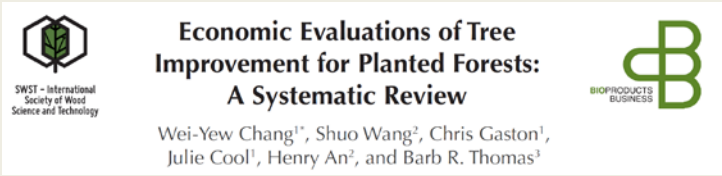
RES-FOR HIGHLIGHT #2

March 2019

Economic Evaluations of Tree Improvement for Planted Forests: A Systematic Review

Overview

Planted forests play an important role in sustainable forest management and can help to fulfil a wide variety of social, economic, and environmental objectives. As planted forests become more common, it makes economic sense to improve the quality of seed and subsequent seedling stock used, which includes planting improved (superior) trees rather than planting unimproved seed and seedling stock year after year. Using improved seedling stock also creates economic incentives for investors to pursue plant domestication and tree improvement activities to capture the benefits of these improvements and innovations.

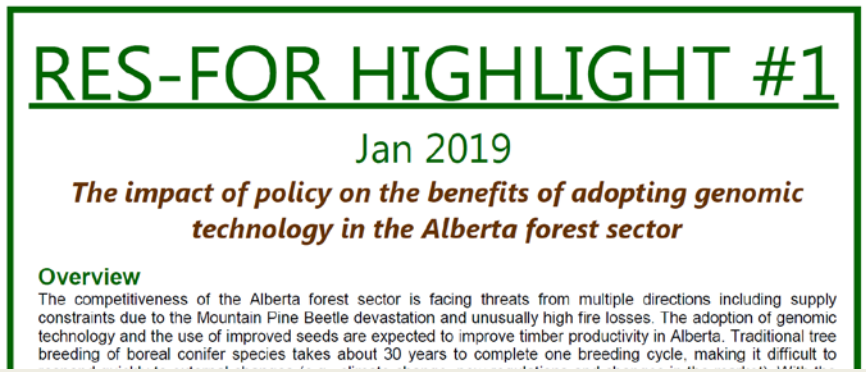


SWST – International Society of Wood Science and Technology

Economic Evaluations of Tree Improvement for Planted Forests: A Systematic Review

BIOPRODUCTS BUSINESS

Wei-Yew Chang[1*], Shuo Wang[2], Chris Gaston[1], Julie Cool[1], Henry An[2], and Barb R. Thomas[3]



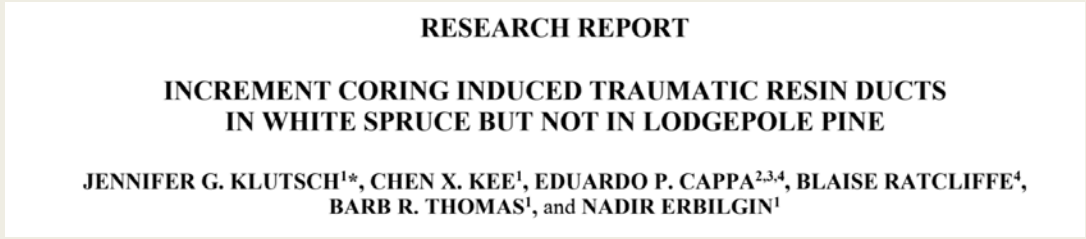
RES-FOR HIGHLIGHT #1

Jan 2019

The impact of policy on the benefits of adopting genomic technology in the Alberta forest sector

Overview

The competitiveness of the Alberta forest sector is facing threats from multiple directions including supply constraints due to the Mountain Pine Beetle devastation and unusually high fire losses. The adoption of genomic technology and the use of improved seeds are expected to improve timber productivity in Alberta. Traditional tree breeding of boreal conifer species takes about 30 years to complete one breeding cycle, making it difficult to



RESEARCH REPORT

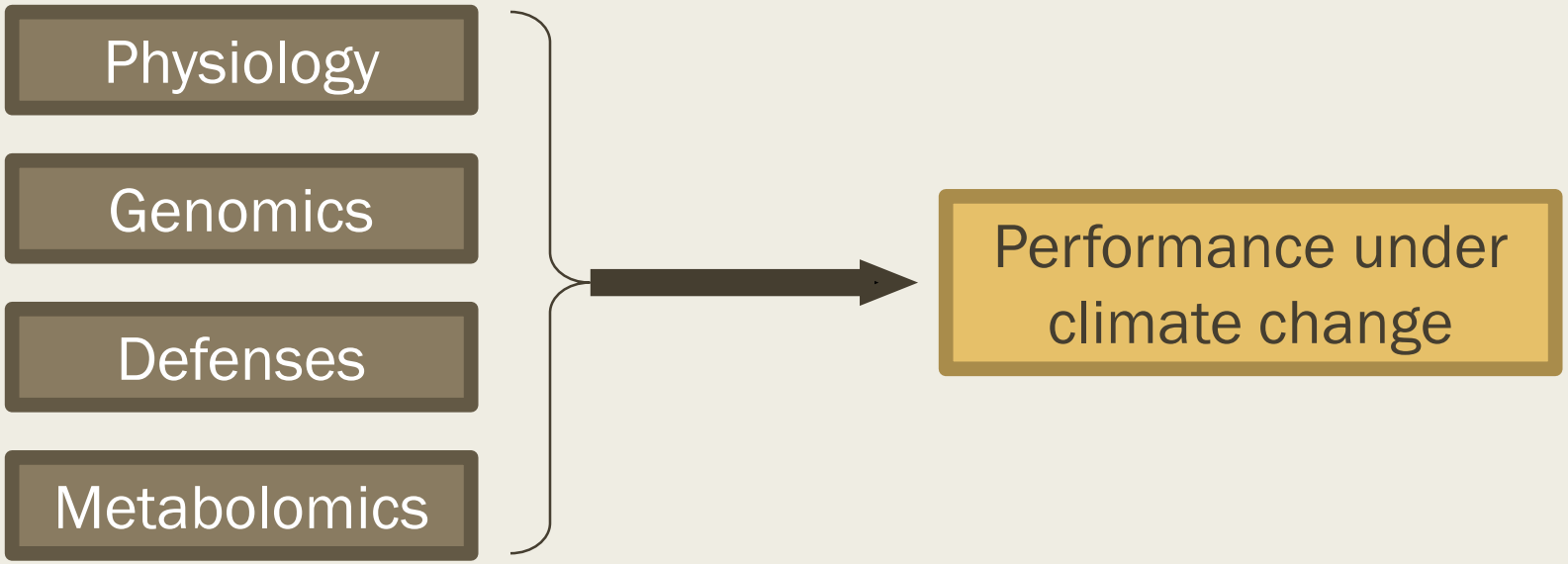
INCREMENT CORING INDUCED TRAUMATIC RESIN DUCTS IN WHITE SPRUCE BUT NOT IN LODGEPOLE PINE

JENNIFER G. KLUTSCH[1]*, CHEN X. KEE[1], EDUARDO P. CAPPA[2,3,4], BLAISE RATCLIFFE[4], BARB R. THOMAS[1], and NADIR ERBILGIN[1]

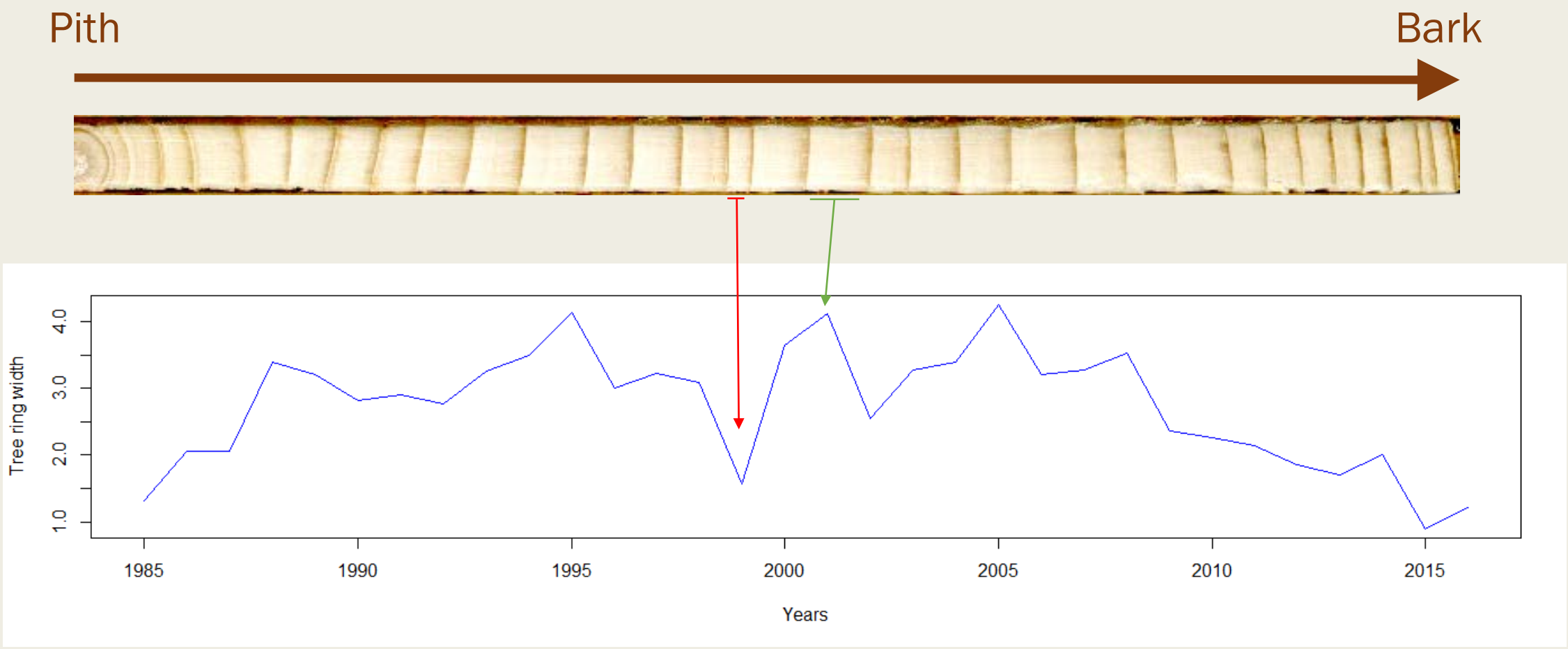
Everything available at our website: https://resfor.ualberta.ca/

My job within RES-FOR

Activity 6.5: Deployment implications of genomic selection under climate change



Dendrochronology

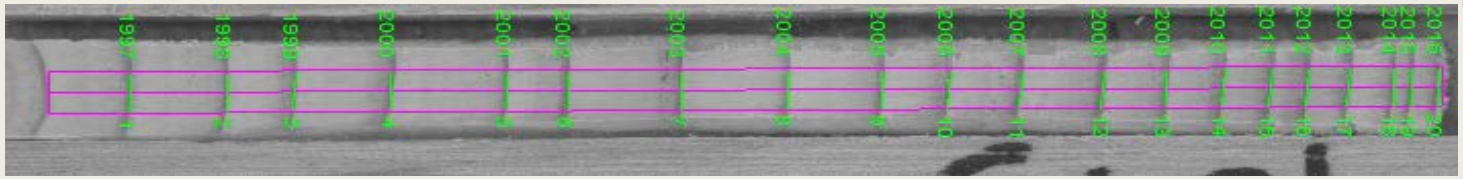


Methodology

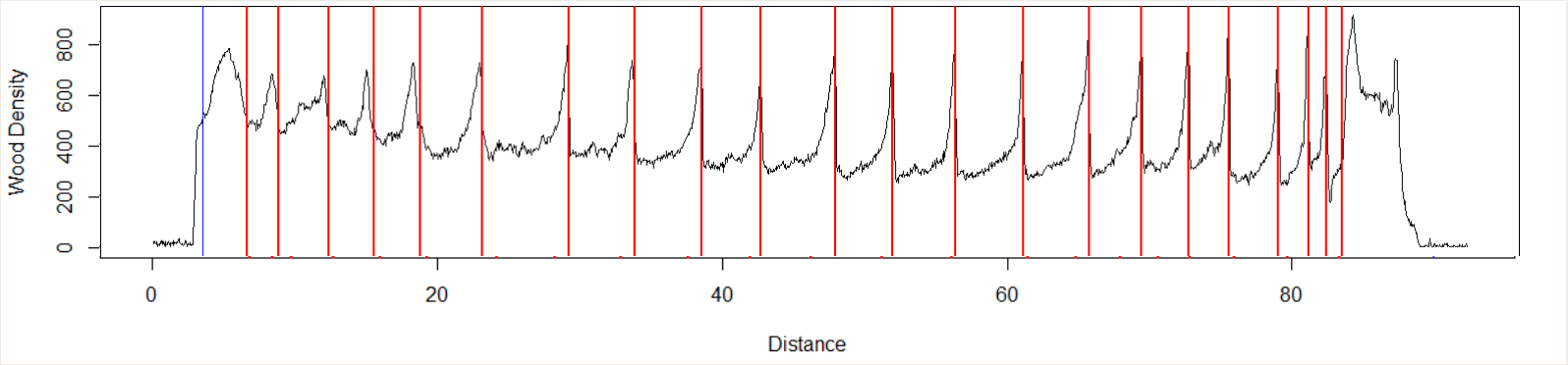
- Ring widths of 10 pine and 10 spruce families measured directly

Pith

Bark

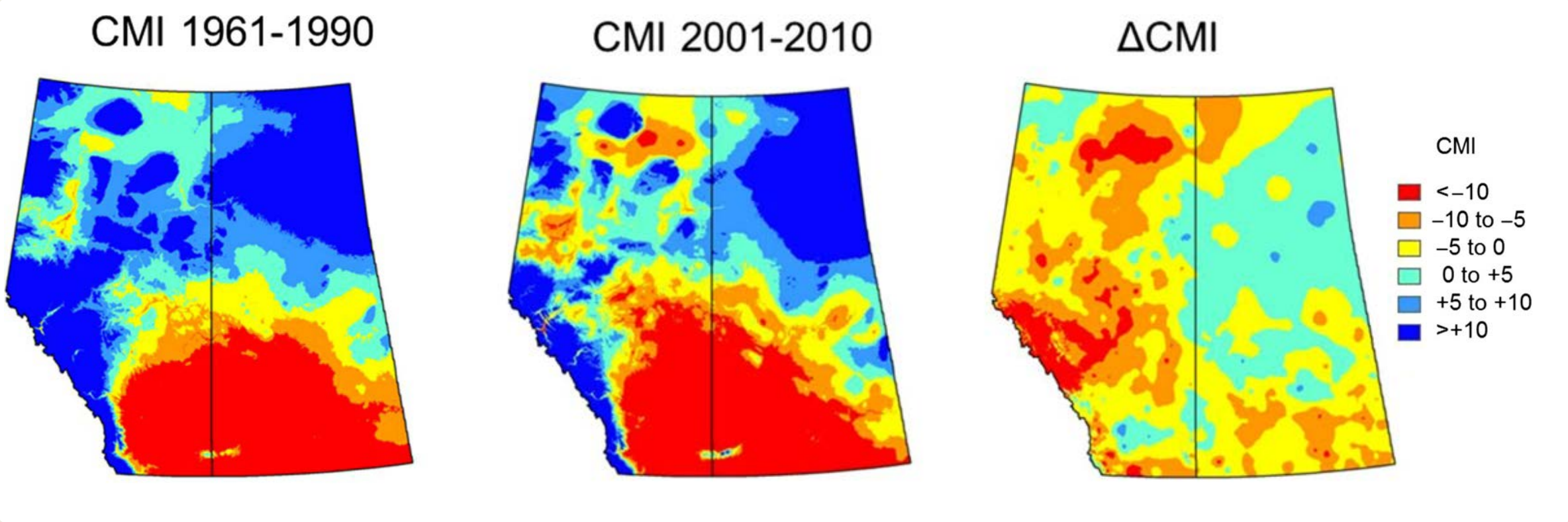


- X-ray densitometry profiles for all the trees (Dr. Mansfield lab at UBC)

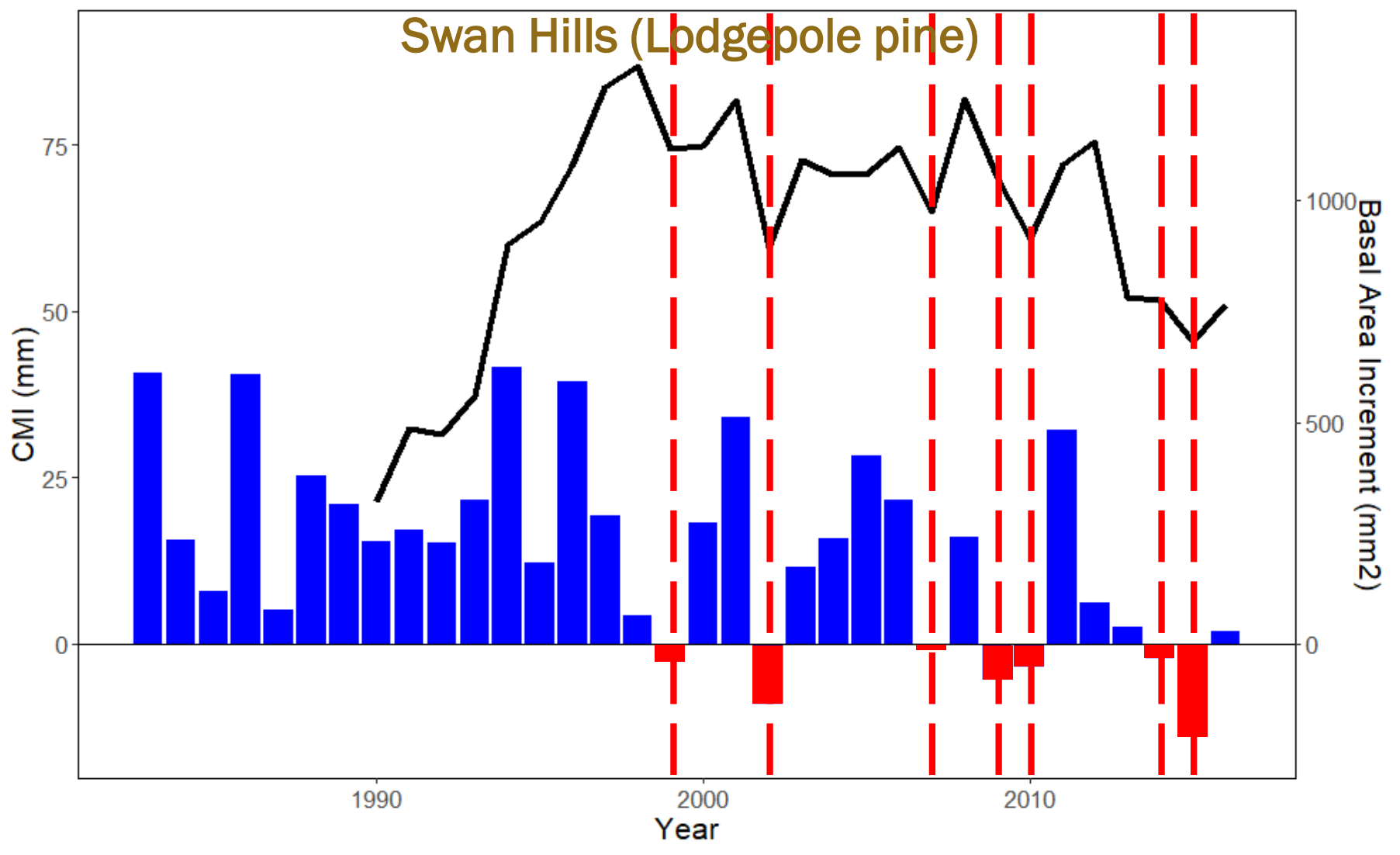


Climate Moisture Index trend

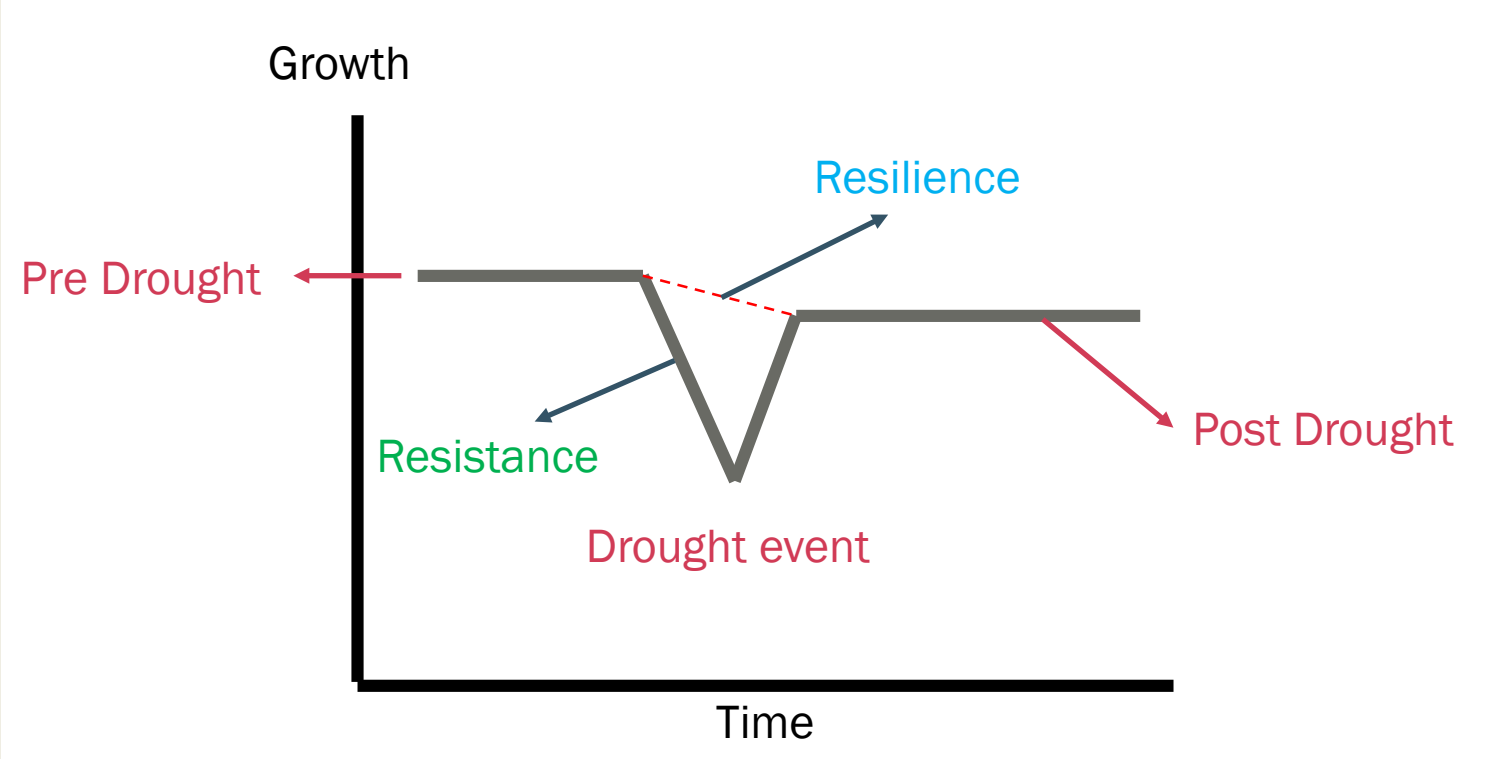
CMI = Precipitation – Potential Evapotranspiration



Drought effect on tree growth



Resistance and Resilience to drought

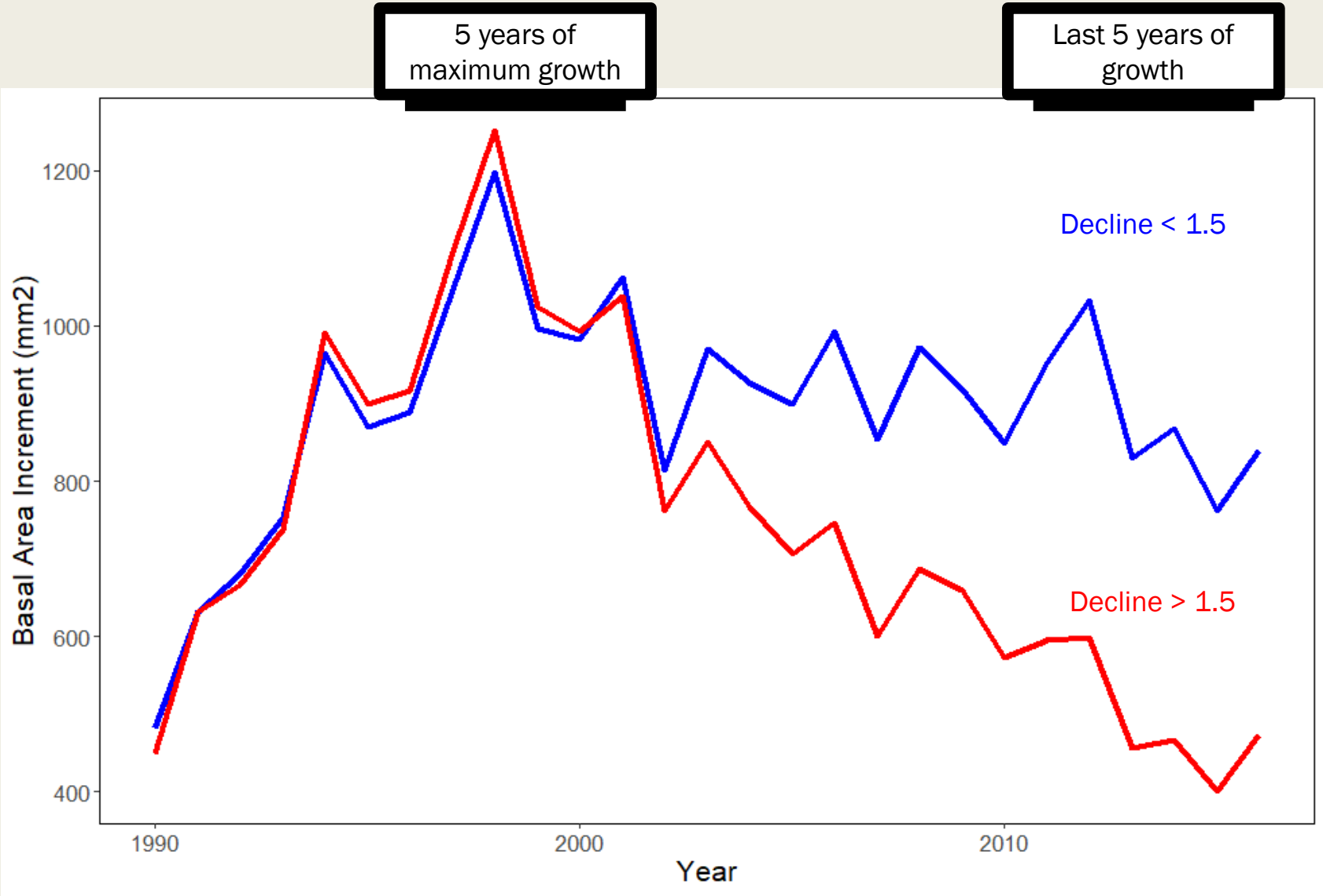


Resistance = Drought / Pre Drought

Resilience = Post Drought / Pre Drought

Modified from Lloret, Keeling and Sala (2011)

Long term decline



Decline = Max Growth / Last Growth

Short and long term response to drought

- Comparing resistance/resilience to a single drought and the decline index we can infer if a single drought stress can have an effect on the long term performance of the tree
- Resilience to different drought years were all individually correlated to decline, but they were not correlated to each other
- We need more analyses to determine if long term decline is caused by a single drought stress from which trees are not able to recover or due to the accumulation of multiple drought events

Effect of competition and disease on long term decline

- Preliminary analyses show that sites with high competition had a higher proportion of trees showing high decline
- Trees severely affected by western gall rust also showed higher decline
- A combination of multiple stresses might contribute to long term growth decline

Why do some trees decline?

- Single drought causing a ‘tipping point’ or accumulated stress of multiple droughts?
- The chicken or egg dilemma: are trees suffering competition/WGR more susceptible to decline or are they outcompeted/affected because they are declining?
- *More traits to analyze! Climate effect, Wood density,* ^{13}C*…*

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TREE IMPROVEMENT LAB

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