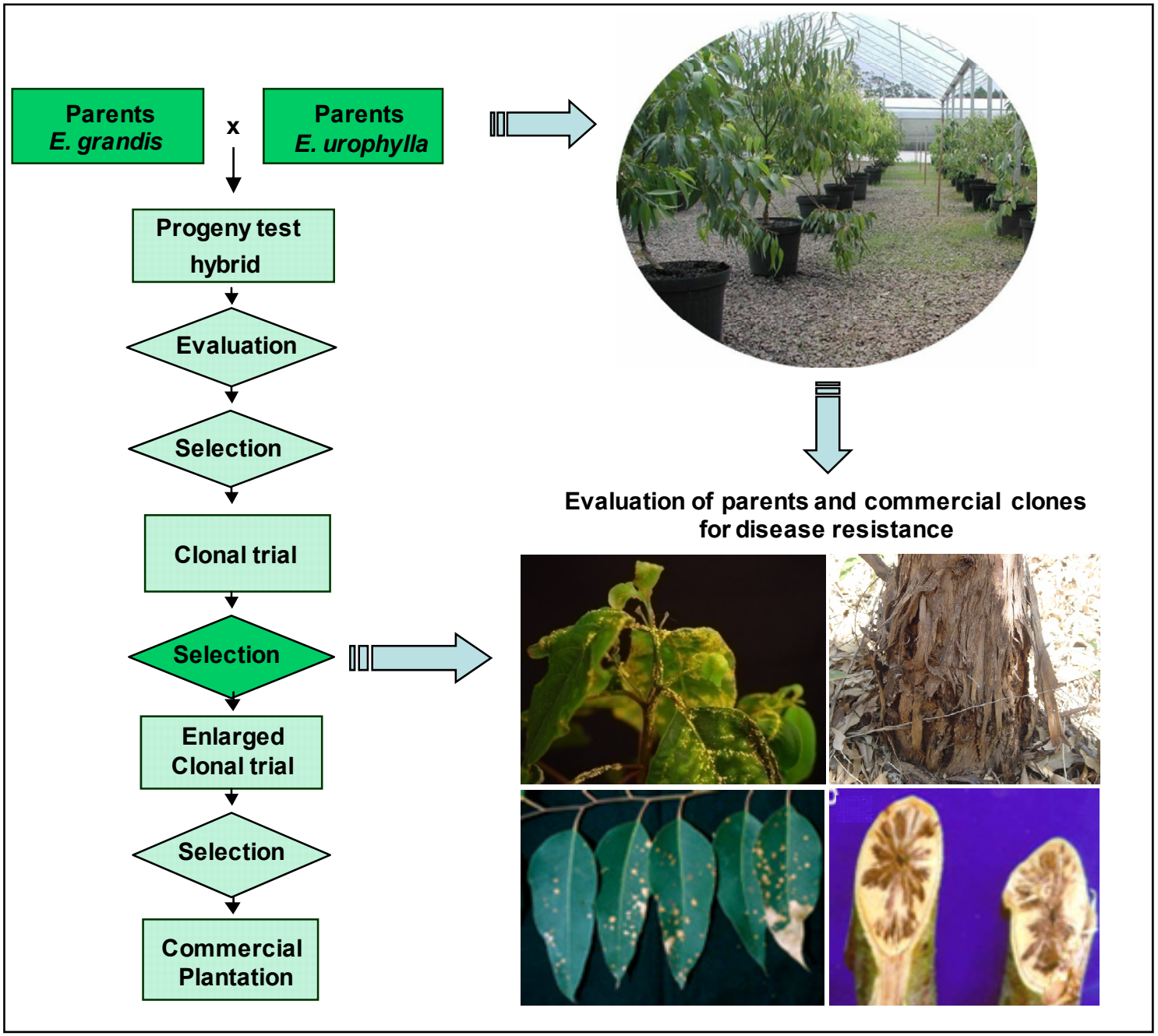
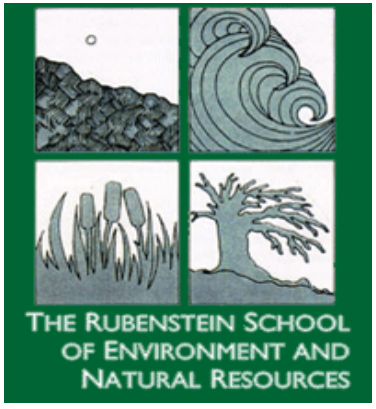
Evaluation of disease resistance in a breeding program



Fonseca et al. (2010)

Genetic Variation in Lodgepole Pine Physical and Chemical Defenses Associated with Host Selection Behaviors of Mountain Pine Beetles

Kimberly Wallin - University of Vermont and USDA Forest Service
Dan Ott - University of Vermont, University of Northern British Columbia
Dezene Huber - University of Northern British Columbia
Alvin Yanchuk - British Columbia Forestry



The UNIVERSITY of VERMONT

Acknowledgments

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Funding sources: BC-Ministry of Forest, USDA Forest Service - Research Branch and Forest Health Protection, McIntire-Stennis, National Science Foundation, USDA National Research Initiative

Three Stages of Bark Beetle Life History

- 1) Host Selection and Colonization
  - –Habitat location
  - –Host location
  - –Host use
- 2) Brood Development
- 3) Dispersal

Host Defenses At Each Stage

- 1) Primary Defenses
  - –Outer Bark
  - –Resin Flow
  - –Constitutive Terpenes
- 2) Secondary Defenses
  - –Compartmentalization of associated fungi
  - –Induced Terpenes
    - –Halt Reproduction

Eggs are deposited in niches along the egg gallery

- Adults may die in the gallery prior to oviposition

Bark beetles carry a variety of microorganisms (fungi, yeasts, and bacteria)

- Blue-stain fungi (Ophiostoma) are common
  - –Aid in tree killing
  - –Serve a nutritional role

2. Brood Development

- Larvae mine at right angles to the egg gallery
  - –3-4 larval instars and late instars stay in phloem or move into outer bark
- Pupate at end of larval mines

3. Dispersal

- Emerge to locate another suitable host
- Strong fliers – can disperse over long distances
- Dispersal is a small fraction of the generation time

Objectives

Examine an important open pollinated family trial using simulated and 'optimum' mountain pine beetle attack attack for discerning genetic variation

Examine variation in 'choice' by mountain pine beetle and resistance / tolerance among families

Estimate genetic parameters for these traits

Examine mechanisms of resistance, to better understand host / bark beetle interactions

- Quantify host resistance traits thought to be linked to MPB attack and successful colonization
- 2 sites with randomized complete block design
- 45 families of interest identified based on preliminary findings
- 8-12 individuals per family per site
- Estimate h^2 defensive responses
-

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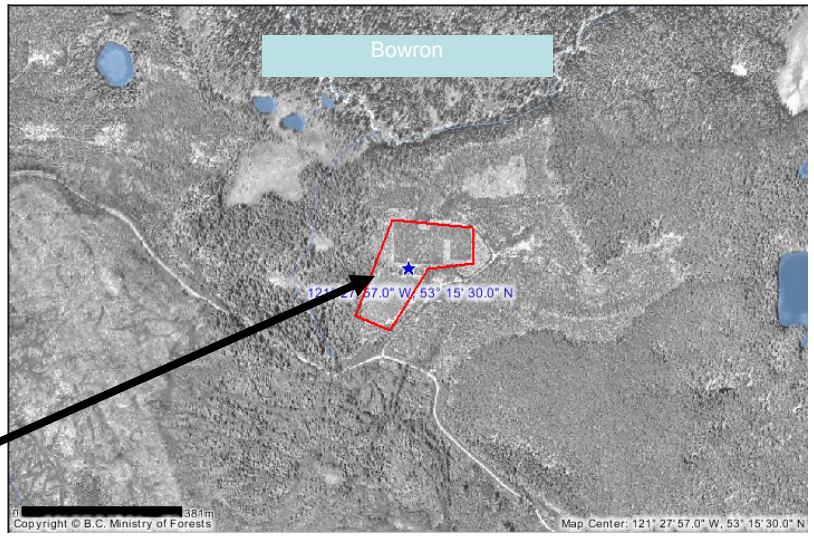
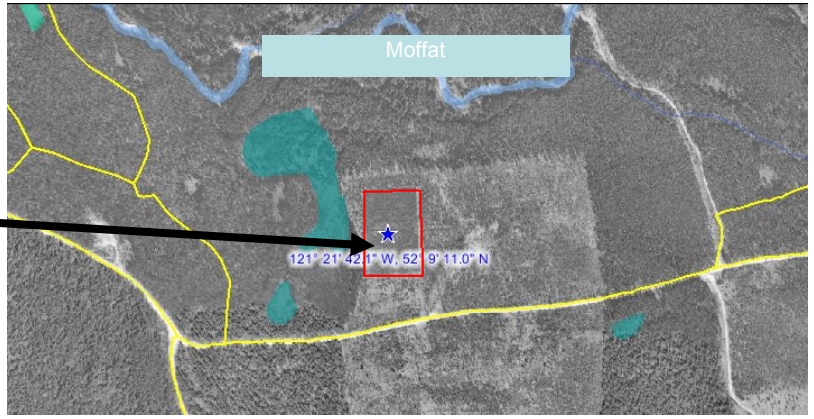


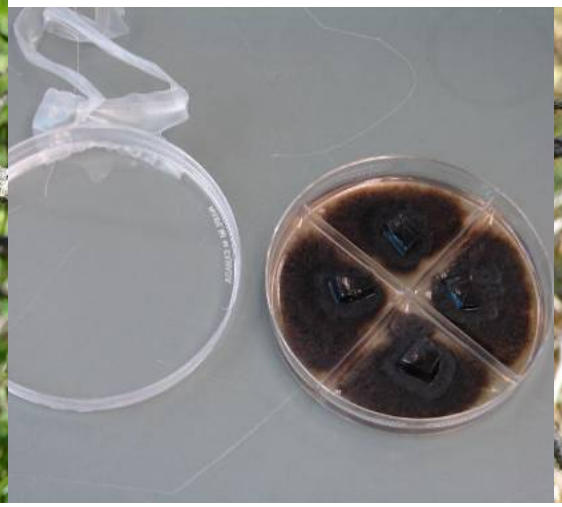


Randomized complete block design – 8 reps with the same families, but individually randomized. Each family placed with 4 individuals in a row.

Simulated attack: 1º and 2º Defenses

Resin Flow:1800+

O. clavigerum – cultivated & inoculated



Tree chemistry – 2800+ samples

Constitutive – phloem collected when resin flow

Induced - phloem during lesion measuring

Actual Mountain Pine Beetle Attack

Host Location: Landed or not landed upon

Host Selection: Landed upon and attacked or not attacked

Brood Development: Ovipositional placement density, including eggs deposited and offspring development

Dispersal: Adults emerging density

Beetle lands on a tree

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Beetle lands on a tree

Does not enter

Enters

Beetle lands on a tree

Does not enter

Enters

Bark texture h^2=0.65

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Beetle lands on a tree

Does not enter

Enters

Bark texture h^2=0.65

Dies

Tree defenses
Primary: Resin flow
Secondary: Terpenes

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Beetle lands on a tree

Does not enter

Enters

Bark texture h^2=0.65

Blue stain lesion h^2=0.24

Dies

Resin volume h^2=0.05

Total terpenes h^2=0.5

3-carene h^2=0.6

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Beetle lands on a tree

Does not enter

Enters

Dies

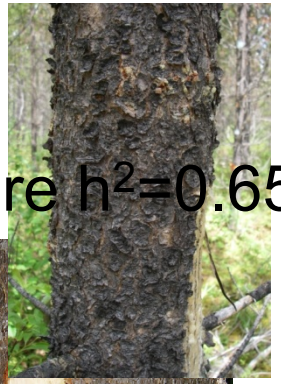
Resin volume h^2=0.05

Total terpenes h^2=0.5

3-carene h^2=0.6

Survives

Bark texture h^2=0.65



Blue stain lesion h^2=0.24

Recruits conspecifics

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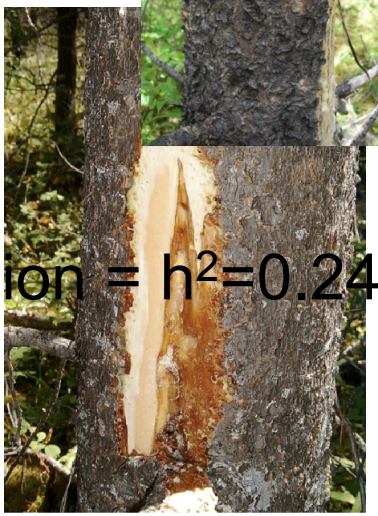
Beetle lands on a tree

Does not enter

Bark Texture h^2=0.65

Enters



Dies

Resin = h^2=0.05

Total terpenes h^2=0.5

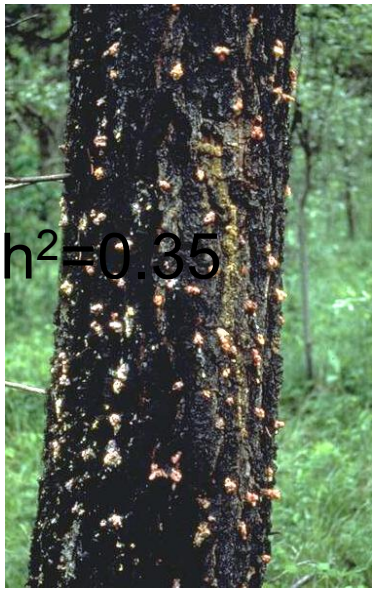
3-carene h^2=0.6

Blue stain lesion = h^2=0.24

Survives

Recruits conspecifics

Terpinolene= h^2=0.35



Success

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Results

- All estimates of heritability for differential attack of MPB on lodgepole pine were generally in the range of the heritability of height at age 10 (i.e., $h^2 = 0.45$) indicating there are moderate to high levels of genetic variation for resistance related traits to MPB
- Resin volume was not a good predictor of insect mortality
- Total terpenes had higher than the general range of heritability
- High levels of δ-3-carene at day 0 significantly correlated with insect mortality and tree survival.

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