Improving forest resilience to climate change and extremes with genetics

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(on behalf of many collaborators)
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Canadian Institute of Forestry
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Enhance resilience with genetics

- Opportunities through reforestation
  - 500 million seedlings planted/yr in Canada
  - One of the most important silviculture decisions
  - Get it right: Which genotypes are best?
  - Screen tree populations for resilience
Forest genetics can enhance resilience

1. Is seed climatically well-suited?
   - Evaluate risk trade-offs to guide **seed transfer**
   - Genetic variation among populations

2. What is the genetic quality?
   - **Tree breeding** and selection
   - Genetic variation within populations
1. Climate suitability
1. Climate suitability
2. Genetic quality

- Seed orchard
  - Select & collect
  - Test in progeny trials
  - Crosses (breeding)
  - Select & collect

Spatial layout of one progeny trial; each cell represents a tree coloured by a response variable.

Douglas-fir range

North America
2. Genetic quality
2. Genetic quality

2. Genetic quality

Phenotyping response to extremes: Tree rings

- Archives of:
  - Growth responses to drought & frost signatures

- Powerful when combined with older forest genetic trials:
  - Same age, same initial planting density
  - High replication – elegant experimental designs
  - Known: Origin and/or parent-offspring relationships
  - Genetic component of variation in responses
Phenotyping response to extremes: Tree rings

1. Climate suitability

1. Climate suitability

- Mechanisms – Cellular properties

Micro section photos by David Montwé @ UBC
1. Climate suitability

Isaac-Renton M et al. 2018. Northern forest tree populations are physiologically maladapted to drought. *Nature Communications.* 9: 5254
1. Climate suitability

Normal ring boundary

Blue ring (fall cold event)

Big blue ring + distortions (severe fall cold event)

Distortions in earlywood (spring cold event)

Isaac-Renton M et al. (In Prep) Selecting suitable seed sources for reforestation in the north.
2. Genetic quality

- Two important, sympatric conifers
- Decades of tree breeding & gain
- Dieback & mortality – drought-induced?
- Field experiments established in 1999

2. Genetic quality

2. Genetic quality

Can we use tree rings to screen tree breeding populations for resilience to drought?
2. Genetic quality

Douglas-fir

Western redcedar

Genetic component behind this variability?
2. Genetic quality

- Heritability: $h^2 = V_G/V_P$

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<table>
<thead>
<tr>
<th>Heritability</th>
<th>Coastal Douglas-fir</th>
<th>Western redcedar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trait</td>
<td>$h^2$</td>
<td>SE</td>
</tr>
<tr>
<td>Height</td>
<td>0.28</td>
<td>0.07</td>
</tr>
<tr>
<td>Resistance</td>
<td>0.19</td>
<td>0.06</td>
</tr>
<tr>
<td>Recovery</td>
<td>0.06</td>
<td>0.05</td>
</tr>
<tr>
<td>Resilience</td>
<td>0.19</td>
<td>0.06</td>
</tr>
<tr>
<td>Relative Resilience</td>
<td>0.10</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Drought resilience moderately heritable

2. Genetic quality

2. Genetic quality

Douglas-fir

Western redcedar

Opportunities to further screen for resilience

2. Genetic quality

Can we use tree rings to screen tree breeding populations for resilience to drought?

- Heritable and variable trait
- No strong genetic trade-offs
- High-yielding and climate-resilient families

YES, but…
Tree ring limitations

- Slow & laborious
  - Wait to evaluate resilience
  - Labour-intensive
  - Facilities not always available

- Lower sample size
  - Reduced precision

Photos by Lori Daniel's Tree-Ring Lab @ UBC
Rapid phenotyping through remote sensing?

• Real-time sensors to detect:
  • Growth, drought and phenology
  • Linked to field climate data

• Aerial phenotyping platform
  • Field trials

• Terrestrial phenotyping platform
  • Raised beds

(Tyrone Keep. U of S Plant Phenotyping and Imaging Research Centre (P^2IRC) -tyrone.keep@usask.ca)
Take aways

- Enhance resilience through seed transfer and genetic selection
  - Climate warming & extremes
  - Growth, drought and frost risk - tree rings

- Faster alternatives to phenotype response to extremes needed

- Multiple approaches

- Benefits to mitigating impacts
Thanks to a great team!

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BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development


...and many more!

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Questions?

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