The NSERC TRIA Network
Turning Risk Into Action for the
Mountain Pine Beetle Epidemic

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and the Tria Consortium
TRIA: Turning Risk Into Action for the Mountain Pine Beetle Epidemic

TRIA 1
2008-2009

TRIA 2
2009-2013

TRIA-Net
2013-2018
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TRIA-Net Partners

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Foothills Research Institute
Manitoba Conservation and Water Stewardship
Natural Resources Canada - Canadian Forest Service
Northwest Territories Department of Environment and Natural Resources
Ontario Ministry of Natural Resources
Saskatchewan Ministry of Environment
West Fraser
Weyerhaeuser

TRIA-Net
Turning Risk Into Action for the Mountain Pine Beetle Epidemic
TRIA-Net research addresses MPB range expansion into novel habitats

Will MPB population dynamics differ in novel habitats?
TRIA-Net Overview

- **MPB**
- **Pine host**
- **Fungal associates**

TRIA-Net

Turning Risk Into Action for the Mountain Pine Beetle Epidemic
TRIA-Net Overview

How gene products work to shape organism responses

Theme 1
Molecular Analyses

MPB

Genetic variation across landscapes

Theme 2
Population Genomics

How organisms function & interact in nature

Theme 3
Ecosystem Dynamics

Pine host

Fungal associates

Theme 4
Socioeconomic Analyses

How organisms function & interact in nature

TRIA-Net
Turning Risk Into Action for the Mountain Pine Beetle Epidemic
TRIA-Net Overview

How gene products work to shape organism responses

Theme 1 Molecular Analyses

Theme 2 Population Genomics

Theme 3 Ecosystem Dynamics

Theme 4 Socioeconomic Analyses

MPB

Genetic variation across landscapes

Risk Assessment, Monitoring, Prediction

Partners

Policy development

Spread control planning (DSS)

Forest management planning

National Forest Pest Strategy

How organisms function & interact in nature

How gene products work to shape organism responses

Pine host

Fungal associates

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Turning Risk Into Action for the Mountain Pine Beetle Epidemic
How do genetics and the environment affect pine defenses against MPB?

This part of the curve is affected by host genetics and environment.
How do genetics and the environment affect pine defenses against MPB?

Hypothesis 1: Co-evolved hosts have acquired defenses & other traits that render greater protection than naïve hosts.
How do genetics and the environment affect pine defenses against MPB?

Hypothesis 2: Drought and other stresses have a measurable impact on host susceptibility.

Hogg’s climate moisture index
How do genetics and the environment affect pine defenses against MPB?

Hypothesis 3: Genetic introgression influences pine susceptibility to MPB

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Turning Risk Into Action for the Mountain Pine Beetle Epidemic
Lodgepole and jack pine present different defenses, but does the beetle care?

**Seedlings**

- **Lodgepole pine**
  - Days post inoculation: 7, 14, 56, 68
  - Well watered
  - Water deficit

- **Jack pine**
  - Days post inoculation: 7, 14, 56, 68

**Mature trees**

- **Lodgepole pine**
  - Days post inoculation: 20, 50, 70
  - Well watered
  - Water deficit

- **Jack pine**
  - Days post inoculation: 20, 50, 70
Are there genetic signatures for selection associated with MPB range expansion, suggesting adaptation to novel habitats?

Do the mechanisms that larvae use to overwinter differ between naïve vs. co-evolved hosts?

Frequency 5%

Frequency 20%
What factors influence MPB dispersal?

Are there genetic variants associated with dispersal traits?

Lorraine Maclauchlin, Maya Evenden group

TRIA-Net: Turning Risk Into Action for the Mountain Pine Beetle Epidemic
Mountain pine beetle outbreaks are rare in its native range.

Between outbreaks, populations persist in an endemic state.
MPB in its native range: distinct population states

**Endemic populations**
- Low densities (rare)
- Preferential attack of small-diameter, vigour-impaired trees previously attacked by other beetle species
- Negative feedbacks predominate; mortality and brood production balanced

**Epidemic populations**
- High densities (widespread)
- Preferential attack of large, healthy trees (mass attacks) in the absence of competitors
- Positive feedbacks predominate; 2- to 8-fold annual increases in population size are common

Without a viable endemic niche, populations cannot persist once outbreaks collapse

From: Carroll et al. 2006
The endemic vs epidemic niche in native habitats: altered trophic interactions
[two examples from Carroll et al. (2006)]

- The endemic niche: preferential colonization of trees previously attacked by other bark beetle species
- The endemic niche: preferential colonization of trees with vigour-impairing injuries
Dynamics of endemic mountain pine beetle populations in novel pine habitats

Objectives - Determine the potential for long-term persistence and eruption by MPB in novel pine forests by:

1. quantifying the trophic interactions that form the endemic niche in novel pine habitats;
2. determining the threshold population required to transition to the epidemic state.
Objective 1: Quantifying the endemic niche

3 forest types:
- lodgepole pine (Pl)
- Lodgepole-jack pine hybrid (Pl × Pj)
- jack pine (Pj)

2 infestation states:
- pre-outbreak (newly colonized)
- post-outbreak (population collapse)

“100% cruise” - Carroll et al. (2006)
- Early & late summer census of all trees in candidate stands (ca. 10ha each)
- Locate endemic MPB populations
- Characterize trophic interactions and niche constraints in situ and ex situ (harvest trees, assess presence and role of competitors and natural enemies in laboratory)

Note: post-outbreak Pj stands not currently available, but may arise before study culmination
Objective 2: Determining the threshold population for endemic-epidemic transition

- 3 forest types: Pl, Pl × Pj, Pj
- Initiate mass attacks with commercial lures
- Monitor then cage trees as attack densities reach 10, 20, 30... 80 attacks/m²
- Determine threshold density for successful mass attack by forest type

Attack initiation

Monitor, cage

pheromone lure

10 attacks/m² 20 attacks/m² 80 attacks/m²
## Project schedule 2014

<table>
<thead>
<tr>
<th>Activity</th>
<th>Dates</th>
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</thead>
<tbody>
<tr>
<td>Site/stand selection, 1 each:</td>
<td>March - May</td>
</tr>
<tr>
<td>‟ Pl (pre- &amp; post-outbreak);</td>
<td></td>
</tr>
<tr>
<td>‟ Pl × Pj (pre- &amp; post outbreak);</td>
<td></td>
</tr>
<tr>
<td>‟ Pj (pre-outbreak)</td>
<td></td>
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<tr>
<td>Stand mensurational measurements..............................................</td>
<td>June</td>
</tr>
<tr>
<td>100% cruises, <em>in situ</em> niche assessment</td>
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</tr>
<tr>
<td>‟ Early summer..........................................................................</td>
<td>July</td>
</tr>
<tr>
<td>‟ Late summer..........................................................................</td>
<td>September</td>
</tr>
<tr>
<td><em>Ex situ</em> niche assessment (laboratory rearing of harvested bolts).....</td>
<td>September - December</td>
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</tbody>
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Applying TRIA-Net outcomes
Applying TRIA-Net outcomes

Stand susceptibility risk models
Statistical spread risk models
Process-based spread risk models

Cost-benefit analyses of intervention strategies and management practices based on ranges of estimated ecosystem service values
Mountain pine beetle at the leading edge of the outbreak: new surprises at every turn

Lorraine Maclauchlin, BC Ministry of Forests and Range

Rory McIntosh, Saskatchewan Environment
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Catalyst for research and response