Tree mortality patterns in *Picea mariana* forests during transition stages in two regions of boreal Quebec

Nicolas Fauvart, Alain Leduc and Yves Bergeron
Black spruce forest dynamics

Stand initiation ➔ Stem exclusion ➔ Canopy transition ➔ Gap dynamics

DW abundance

Time since fire
Black spruce forest dynamics

Stand initiation → Stem exclusion → Canopy transition → Gap dynamics

Time since fire → DW abundance
Black spruce forest dynamics

Stand initiation  →  Stem exclusion  →  Canopy transition  →  Gap dynamics

DW abundance

Time since fire

Images of forest conditions at different stages.
Black spruce forest dynamics

Stand initiation

Stem exclusion

Canopy transition

Gap dynamics

DW abundance

Time since fire
Black spruce forest dynamics

Stand initiation → Stem exclusion → Canopy transition → Gap dynamics

DW abundance

Time since fire
Origin of mortality

Decline disease spiral from Manion (1991)
Origin of mortality

**ENDOGENOUS**
- Senescence
- Resource access (competition, fertility)

**EXOGENOUS**
- Biotic
  - Spruce budworm outbreaks
  - Decay
- Abiotic
  - Climate (wind, drought, frost)

DEATH
Objectives

• Characterize and compare the temporal patterns of mortality between 2 regions.

• Determine the factors influencing the patterns observed.
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Hypotheses

Synchronous and discontinuous mortality  
Exogenous factors

Asynchronous and continuous mortality  
Endogenous factor
Objectives

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Hypotheses

Synchronous and discontinuous mortality
Exogenous factors

Pulsating

Asynchronous and continuous mortality
Endogenous factor
### Material and Methods

**Abitibi Northern Lac St-Jean**

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>n. of sites</td>
<td>11</td>
</tr>
<tr>
<td>Age (time since fire)</td>
<td>132 to 234 years</td>
</tr>
<tr>
<td>Drainage</td>
<td>imperfect</td>
</tr>
<tr>
<td>Soil texture</td>
<td>fine</td>
</tr>
<tr>
<td>Thickness of organic matter</td>
<td>&lt; 40 cm</td>
</tr>
<tr>
<td>n. of sites</td>
<td>16</td>
</tr>
<tr>
<td>Age (time since fire)</td>
<td>120 to 288 years</td>
</tr>
<tr>
<td>Drainage</td>
<td>moderate</td>
</tr>
<tr>
<td>Soil texture</td>
<td>coarse</td>
</tr>
<tr>
<td>Thickness of organic matter</td>
<td>&lt; 40 cm</td>
</tr>
</tbody>
</table>
Sampling and measurements

• **Deadwood**

  ✓ All deadwood potentially datable, 2 disks/tree (base & top), DBH, height, decomposition classes, description (snag, log, uprooted...)

  ✓ Disks were dried and sanded

  ✓ Year-of-death was cross-dated and verified statistically
Tree mortality

• Dynamics of mortality
  ✓ Annual relative mortality rate

• Causes
  ✓ Climate influences
    • Temperature
    • Precipitation
    • Wind
  ✓ Spruce budworm outbreak influence

• Intensity of mortality

Compared with mortality dynamics
### Sampling and measurements

<table>
<thead>
<tr>
<th></th>
<th>Abitibi</th>
<th>Northern Lac St-Jean</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead trees sampled &amp; (disks)</td>
<td>215 (393)</td>
<td>280 (547)</td>
<td>495 (940)</td>
</tr>
<tr>
<td>Successfully cross-dated dead trees &amp; (disks)</td>
<td>208 (373)</td>
<td>255 (498)</td>
<td>463 (832)</td>
</tr>
<tr>
<td>Dead trees with last ring present &amp; (disks)</td>
<td>194 (324)</td>
<td>233 (463)</td>
<td>427 (787)</td>
</tr>
<tr>
<td>Percentage of trees with years of death</td>
<td>90 %</td>
<td>83 %</td>
<td>86 %</td>
</tr>
</tbody>
</table>
Mortality patterns from 1985 to 2009 in Abitibi & Northern Lac Saint-Jean

**Abitibi**
Mean = 0,95% (SD 1,40%)

**Northern Lac Saint-Jean**
Mean = 0,88% (SD 1,49%)
Mortality pattern from 1985 to 2009 in Northern Lac Saint-Jean

Climate influence

Influence of mean temperature
- July (t-1 & t)
- Spring (t)

Influence of total precipitation
- June (t-1 & t)
Mortality pattern from 1985 to 2009 in Abitibi

Climate influence

Influence of mean temperature
  •  - july (t-1 & t)
  •  + spring (t)

Influence of total precipitation
  •  + June (t-1 & t)
Mortality pattern from 1985 to 2009 in **Abitibi**

**Wind influence**

29% of dead trees were uprooted or broken by wind
Mortality pattern from 1985 to 2009 in **Northern Lac Saint-Jean**

**Wind influence**

13% of dead trees were uprooted or broken by wind
Mortality patterns from 1985 to 2009 in Abitibi & Northern Lac Saint-Jean

Spruce Budworm outbreak influence

Peak of the outbreak: 1978-1979
Severity of single event of mortality

- 19 events with a rate > 5%
- 80 % of trees died in event of low severity (0-1 to 3-4%)
• The factors involved in mortality are numerous and difficult to identify

✓ Stress caused by climate variability seems to play an important role in tree mortality

✓ Wind plays an important role in tree mortality

✓ Spruce budworm outbreaks. An absence of evidence is not an evidence of absence...
• Rates and variability of tree mortality are relatively stable
  ✓ Years of low severity are dominant
  ✓ Years of highest severity are rare but contribute to mortality

Continuous mortality constitute the background of mortality

Synchronous events of mortality are present but infrequent

Pulsating pattern
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