A model of the post-fire recruitment of *Picea mariana* and *Pinus banksiana* as a function of salvage timing and intensity

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Fire and the Boreal forest
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- Fire is the dominant disturbance in the boreal forest of North America

- Return time: 50 – 250 years
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  *Picea mariana* (black spruce) (Semi serotinous)

  *Pinus banksiana* (jack pine) (Fully serotinous)

- Possess aerial seedbanks
Salvage

• The harvesting of charred trees following fire

• Recuperates economic losses associated with fire

• Intensive and extensive

• Typically applied in the first autumn and winter post-fire to avoid degradation due to wood-boring insects, stain fungi, wood-decay fungi, and checking
Negative effects
Negative effects

1. Poor conifer recruitment

2. Negative effects of removal of wood on dead-wood-dependent species
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1. Poor conifer recruitment

2. Negative effects of removal of wood on dead-wood-dependent species

3. Changes in hydrologic regime

4. Altered soil characteristics

5. Road network expansion
Poor conifer regeneration in salvaged stands due to:
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1. Loss of first cohort due to salvage operations
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• A seedling density of ~1/m² or greater considered adequate to fully re-stock stands (Greene et al. 2002)
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2. Test the model using data from three fires in the boreal forest of North America.
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4. Model the effect of distributing salvaged seed.
General approach

• Developed using the modeling software STELLA

• Simulation period: 72 months (6 years)

P. mariana

P. banksiana
Fire month

Fire
Seeds Available

Fire month

Fire

Basal area

Seed mortality due to fire
Seeds Available

- Fire month
- Fire
- Basal area
- Seed mortality due to fire
- Salvage month
- Salvage proportion
- Salvage
Seeds Available

- Fire month
- Basal area
- Seed mortality due to fire
- Salvage month
- Salvage proportion

Seeds on ground

Salvage

Fire
Fire month

Fire

Seed abscission

Seeds Available

Salvage

Seeds on ground

Basal area

Seed mortality due to fire

Salvage month

Salvage proportion
Seeds Available

- Fire month
- Fire
- Seed abscission

Seeds on ground

- Seeds per seedbed
- Salvage
- Basal area
- Seed mortality due to fire
- Salvage month
- Salvage proportion
Seeds Available

Fire

Seed abscission

Seeds on ground

Seeds per seedbed

Salvage

Seedbed proportions

% Moss
% High porosity
% Mineral soil

Fire month

Basal area

Seed mortality due to fire

Salvage month

Salvage proportion
Seeds Available

Fire

Fire month

Seed abscession

Germination period

Granivory rate

Seed mass

Survivorship function

Seeds on ground

Seeds per seedbed

Seedling density

Salvage

Salvage month

Salvage proportion

Seedbed proportions

% Moss

% High porosity

% Mineral soil

Basal area

Seed mortality due to fire
Model validation

Lebel-sur-Quevillon fire

Observed vs simulated Lebel-sur-Quevillon *P. mariana* and *P. banksiana* recruit density (seedlings/m²) based on treatment

![Graph showing observed vs simulated recruit density](image-url)

- **BS Intact**
- **BS 50% salvaged Dec**
- **BS 100% salvaged Nov**
- **BS 100% salvaged Dec**
- **BS 100% salvaged Jan**
- **BS 100% salvaged Feb**
- **BS 100% salvaged Oct**

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<thead>
<tr>
<th>Treatment</th>
<th>Observed density</th>
<th>Simulated density</th>
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Val Paradis fire (Greene et al. 2006, 2004)

Observed vs simulated Val Paradis *P. mariana* and *P. banksiana* recruit density (seedlings/m$^2$) based on treatment
**P. mariana** age structure Val Paradis (simulated vs observed)

![Graph showing age structure of P. mariana](image1)

**P. banksiana** age structure Val Paradis (simulated vs observed)

![Graph showing age structure of P. banksiana](image2)
Saskatchewan fire (Greene and Johnson 1999)

**Observed vs simulated *P. mariana* recruit densities per m²**

- **Seedling density/m² vs Basal area/area**

**Observed vs simulated *P. banksiana* recruit densities per m²**

- **Seedling density/m² vs Basal area/area**
The year of 100% winter salvage in which minimally full stocking can be obtained given the pre-fire basal area/area.

- **Salvage year P. mariana**
- **Salvage year P. banksiana**
Maximum salvage proportion per year for *P. mariana* to achieve 1 seedling/m² vs the pre-fire basal area/area

**Salvage proportion**

<table>
<thead>
<tr>
<th>Basal area/area</th>
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<th>Year 2</th>
<th>Year 3</th>
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Maximum salvage proportion per year for *P. banksiana* to achieve 1 seedling/m² vs the pre-fire basal area/area

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**P. mariana** seedling densities vs year with distribution of salvaged seeds (75%) and 100% salvage

![Graph showing seedling densities vs year with distribution of salvaged seeds for P. mariana.](image)

**P. banksiana** seedling densities vs year with distribution of salvaged seeds (75%) and 100% salvage

![Graph showing seedling densities vs year with distribution of salvaged seeds for P. banksiana.](image)
Implications
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• Planting almost always necessary following first winter salvage for black spruce
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• Distribution of salvaged seeds presents a promising alternative to planting, as does partial or delayed salvage
Problematic legislation
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• Wood affected by checking, stain fungi, and insect damage can still be used for pulp
Environment and Economy, a delicate balance

• Most pyrophilous insects and fire-associated woodpeckers are abundant for only 2-3 years following fire (St-Germain and Greene 2009)

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1a. Delay salvage 2-3 years in stands where the majority of trees are not suitable for saw-logs, for pulp and paper

1b. Stands with large tree diameters should be salvaged first winter for saw-logs
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3. Delay salvage until the second or third winter, to be used for pulp only. Satisfy saw-log demand using traditional harvest methods
Future research
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• Directly compare the cost of artificial regeneration vs the cost in lost or devalued wood, given a salvage delay
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• Translate model results onto forest inventory maps
Merci!