Similarities and differences between natural post-fire and post-harvest regeneration on upland sites in Alberta: what does this mean for the future?

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Aspen regenerates quickly by suckering
White spruce:

- Seed source (masting species)
- Mineral soil seedbeds
- Can regenerate immediately post-fire (0 – 5 yrs) or later (35+ yrs on rotten logs)

Harvesting fire-origin stands

Juvenile data from post harvest stands

Mature data from fire-origin stands

Data are needed!
Objectives

• Quantify range of variation in post-fire regeneration in boreal mixedwoods
• Comparison between post-fire and post-harvest regeneration
What is the species composition and structure 10 to 20 years post fire?
Stands sampled 10, 13, 20 years post-fire

<table>
<thead>
<tr>
<th>Fire</th>
<th>Year</th>
<th>Size (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chip Lake</td>
<td>1998</td>
<td>10,886</td>
</tr>
<tr>
<td>OChiese</td>
<td>1988</td>
<td>7,646</td>
</tr>
<tr>
<td>Virginia Hills</td>
<td>1998</td>
<td>163,138</td>
</tr>
<tr>
<td>Mariana Lakes</td>
<td>1995</td>
<td>132,679</td>
</tr>
<tr>
<td>Mitsue</td>
<td>1998</td>
<td>49,670</td>
</tr>
</tbody>
</table>

Stratification of sample areas within fires - by pre-fire cover type

2 - 4 ha patches:
- Conifer (white spruce) – dominated
- Conifer-leading mixedwood
- Deciduous-leading mixedwood
- Deciduous (aspen) dominated

504 sampled plots in five fires
Sampling: Standard regeneration survey protocol – plus additional data

Stocking (10m² plot):
C: 1+ conifer > 0.3 m
MX: 1+ conifer and 1+ deciduous tree > 0.3m
D: 1+ deciduous tree > 0.3m
NSR: no trees > 0.3m (unstocked)

Density per species (trees > 0.3 m height)
Semi-quantitative density: white spruce < 0.3 , height

Future crop tree(s): species of the tallest conifer and tallest deciduous (> 0.3 m)

Height of tallest conifer and deciduous

Competition: cover of alder, willow, grass
Stocking

- **Pre-fire cover type**
- **Number of plots** after 10-13 years and after 20 years

At least one conifer/deciduous tree of minimum height 0.3 m

Pre-fire cover type

Legend:
- D
- MX
- C
- NSR (unstocked)
Stocking - species composition (trees of required height)

Aspen
Birch
Aspen/pine
Birch/pine
Aspen/spruce
Birch/Spruce
Pine
Spruce
Black spruce

0.0 0.2 0.4 0.6 0.8 1.0
10-13 years
20 years

NSR
D
DC
CD
C

10-13 years
20 years
Key Findings

High variability in the regeneration composition between and within fires and pre-fire cover types.

Stands with a deciduous component pre-fire regenerated mostly to deciduous

Pre-fire pure conifer (white spruce) stands had the highest proportion of unstocked plots
Key Findings

- Stands with a conifer component pre-fire more often regenerated to a mixture but...

- When conifer regeneration occurred it was almost always pine even when there was no pine component in the pre-fire forest inventory.

- In the 20 yr old fire we found some small white spruce (around 30 cm); almost none in 10 to 13 year old fires.
Comparison of post-harvest vs post-fire

Pre-disturbance cover type: C or CD
Post-harvest regeneration: all planted to white spruce, tended and untended stands (data from Feng et al. 2005)

Paired fires with nearby harvested areas:

Chip Lake (CL) vs Weyerhaeuser Pembina (WeyPB)
Mitsue Fire (MI) vs Alberta Plywood
Virginia Hills (VH) vs Millar Western

Meta analysis
% of plots stocked to white spruce and/or aspen

<table>
<thead>
<tr>
<th>Stocking</th>
<th>Post-fire</th>
<th>Post-harvest Tended*</th>
<th>Post-harvest Untended*</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>3</td>
<td>52</td>
<td>7</td>
</tr>
<tr>
<td>MX</td>
<td>6</td>
<td>41</td>
<td>74</td>
</tr>
<tr>
<td>D</td>
<td>61</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>NSR</td>
<td>30</td>
<td>1</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*Alternative Regeneration Standard 2009 – plots with Aw and Sw
SMD (standardized mean difference): Postharvest minus postfire

null hypothesis (zero difference)

SMD 95% confidence interval

<table>
<thead>
<tr>
<th>Dataset</th>
<th>SMD</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL_WeyPB</td>
<td>-0.48</td>
<td>[-0.73, -0.24]</td>
</tr>
<tr>
<td>ML_AbPI</td>
<td>-0.91</td>
<td>[-1.32, -0.51]</td>
</tr>
<tr>
<td>VH_MW</td>
<td>-1.28</td>
<td>[-1.69, -0.87]</td>
</tr>
<tr>
<td>RE Model</td>
<td>-0.85</td>
<td>[-1.24, -0.47]</td>
</tr>
</tbody>
</table>

Randomization to test for overall significance

0.2 small effect
0.5 medium effect
0.8 large effect
Deciduous density: post-harvest vs post-fire

Untended

Not sig.

Tended

P < 0.0001
Large effect
Post-harvest: lower density
Conifer density: post-harvest vs post-fire

Untended

Tended

Not sig.
## Density (trees/ha)

<table>
<thead>
<tr>
<th>Stocking</th>
<th>Conifer/deciduous</th>
<th>post-fire</th>
<th>post-harvest tend</th>
<th>post-harvest no tend</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>C</td>
<td>387</td>
<td>4,862</td>
<td>4,440</td>
</tr>
<tr>
<td></td>
<td>White spruce</td>
<td></td>
<td>Any conifer</td>
<td></td>
</tr>
<tr>
<td>MX</td>
<td>D</td>
<td>12,363</td>
<td>6,585</td>
<td>12,606</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>224</td>
<td>4,436</td>
<td>6,738</td>
</tr>
<tr>
<td></td>
<td>White spruce</td>
<td></td>
<td>Any conifer</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>D</td>
<td>13,084</td>
<td>7,352</td>
<td>11,852</td>
</tr>
</tbody>
</table>

## Tallest tree: size at performance age

<table>
<thead>
<tr>
<th></th>
<th>Aspen</th>
<th>White spruce</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Post- fire (10-13 yrs)</td>
<td>Tended (12-13 yrs)</td>
</tr>
<tr>
<td>Av Ht (m)</td>
<td>4.59</td>
<td>3.59</td>
</tr>
<tr>
<td>Max Ht (m)</td>
<td>9.08</td>
<td>8.60</td>
</tr>
<tr>
<td>Av DBH (cm)</td>
<td>2.04</td>
<td>3.94</td>
</tr>
</tbody>
</table>
Key Findings

Post-harvest – higher % of plots stocked to C (tended) or MX (untended)

Post-fire – higher % of plots NSR (but these gaps could be small)

Conifer density post-harvest = post-fire (tended or not tended) BUT RECALL ..post-fire mostly pine
Key Findings

Aspen densities significantly lower in post-harvest tended stands; no difference for untended stands

Tallest aspen:
Untended > post-fire > tended

Tallest spruce:
Tended > undtended > fire
How will these stands develop in the future?
Creating an average post-fire C - CD stand in MGM

Mitsue L (10yr.) Virginia Hills (10yr.) Mariana L (13yr.)
Chip L (10yr.)
Creating an average post-fire C - CD stand in MGM

<table>
<thead>
<tr>
<th>White spruce</th>
<th>C</th>
<th>MX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Av Ht (m)</td>
<td>0.4</td>
<td>0.63</td>
</tr>
<tr>
<td>stDev Ht (m)</td>
<td>0.35</td>
<td>0.49</td>
</tr>
<tr>
<td>Max Ht (m)</td>
<td>0.7</td>
<td>0.94</td>
</tr>
<tr>
<td>Av DBH (cm)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>stDev DBH (cm)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aspen</th>
<th>D</th>
<th>MX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Av Ht (m)</td>
<td>4.63</td>
<td>4.52</td>
</tr>
<tr>
<td>stDev Ht (m)</td>
<td>1.6</td>
<td>1.47</td>
</tr>
<tr>
<td>Max Ht (m)</td>
<td>9.08</td>
<td>7.69</td>
</tr>
<tr>
<td>Av DBH (cm)</td>
<td>2.03</td>
<td>2.05</td>
</tr>
<tr>
<td>stDev DBH (cm)</td>
<td>0.61</td>
<td>0.62</td>
</tr>
</tbody>
</table>
Postfire white spruce & aspen volume: 100 years...

In patch types:
- Pure conifer
- Mixed
- Pure deciduous
- Unstocked

Stand: weighted average

Spruce volume: 117 m³/ha
Aspen volume: 322 m³/ha

Postfire white spruce & aspen volume: 100 years...
Postfire white spruce and aspen volume: 150 years...

In patch types:
- Pure conifer
- Mixed
- Pure deciduous
- Unstocked

Stand:

Spruce volume

Aspen volume

C_TVol

D_TVol
Post-fire white spruce and aspen volume over 150 years (for each regeneration ‘patch’ type and stand total)

**Without ingress**

- **Aspen** 333 m³/ha
- **Mix** 323 m³/ha
- **Whole Stand** 221 m³/ha
- **White Spruce** 117 m³/ha
Stand volume over 150 years (total area weighted by regeneration type)

Postfire: only white spruce and aspen
Key Findings

The model suggests post-fire will have substantially lower volume of white spruce and aspen at rotation age than post-harvest (both tended and untended).

The model suggests post-fire stands will have little ‘pure’ white spruce – most of the volume from deciduous or mixed patches.

Recall post-fire conifer regeneration was predominantly pine.
Recommendations for Forest Management

• In order to learn about natural post-fire dynamics in boreal mixedwood forests a representative set of stands should be left unsalvaged within each fire.

• To provide a seed source for natural white spruce regeneration after fire, individuals or patches of white spruce should be retained (not salvaged).
Recommendations for Forest Management

• Under the natural dynamics of boreal mixedwoods, to get a similar conifer proportion as the pre-disturbance state, a longer rotation would be necessary.

• Under extensive management, allowing lower percentages of white spruce in stands and on the landscape should be considered acceptable in return for higher proportions of mixedwood stands on the landscape.
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