Influence of Initial Spacing and Commercial Thinning on Red Pine Production

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CIF AGM, Pembroke, ON
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Outline:

1. Background
   a) Who, what, when, where, why, how?

2. Effects of initial spacing and commercial thinning on:
   a) Growth & Yield
   b) Products
   c) Products – a closer look at utility pole production

3. Economic Considerations
1: Red Pine Initial Spacing / Commercial Thinning Trial

- aka “AECL Red Pine” or more recently “CNL Red Pine”
- Established 1953 by Will Stiell
- PRF requested to afforest expropriated farmland
- Established red pine spacing trial:
  - 4, 5, 6, 7, 8, 10, 14, and 20-ft spacings
  - 30 PSPs in 1962

![AECL Spacing trial planting 1953](image)
CT trial overlaid in 1982 with 3 target residual BA’s

- Limited area, so not all combinations done
- “…take a series of plantations differing only in density and impose a series of similar densities. …would allow comparison of growth by equal-ages stands which had developed differently up until the time of treatment.”

<table>
<thead>
<tr>
<th>Initial Spacing</th>
<th>Control</th>
<th>Thin to 25.3 m²/ha</th>
<th>Thin to 32.1 m²/ha</th>
<th>Thin to 37.9 m²/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>4’x4’ (1.2m x 1.2m)</td>
<td>364, 365</td>
<td></td>
<td></td>
<td>463, 464</td>
</tr>
<tr>
<td>5’x5’ (1.5m x 1.5m)</td>
<td>373, 374</td>
<td></td>
<td></td>
<td>465, 466</td>
</tr>
<tr>
<td>6’x6’ (1.8m x 1.8m)</td>
<td>371, 372</td>
<td>452, 456</td>
<td>453, 454</td>
<td>451, 455</td>
</tr>
<tr>
<td>7’x7’ (2.1m x 2.1m)</td>
<td>368, 375</td>
<td></td>
<td>458, 459</td>
<td>457, 461</td>
</tr>
<tr>
<td>8’x8’ (2.4m x 2.4m)</td>
<td>376, 377</td>
<td></td>
<td></td>
<td>460, 462</td>
</tr>
<tr>
<td>10’x10’ (3.0m x 3.0m)</td>
<td>366, 378</td>
<td></td>
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<tr>
<td>14’x14’ (4.3m x 4.3m)</td>
<td>367, 369</td>
<td></td>
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<tr>
<td>20’x20’ (6.1m x 6.1m)</td>
<td>385</td>
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</tr>
</tbody>
</table>

% of Max BA: 100% 47% 60% 70%

Google Maps

Red Pine Plantations
2. Effects of initial spacing and commercial thinning

- Study has yielded numerous reports and publications
  - Red Pine: Growth and yield, mensuration, biomass, competition modelling
- Still valuable!
  - 60-year old datasets rare
  - Long-term response data of commercial thinning
  - Go beyond volume and consider products and value
- Recent Activity:
  - 60th yr assessment Mar 2013
  - Utility pole survey fall 2013
  - 4th commercial thinning entry in fall 2013
2.a. Growth & Yield

Site Index ~ 24 m @ 50 years

- Light - 37.9
- Heavy - 25.3
- Moderate - 32.1

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2.a. Growth & Yield

Initial Spacing Trial

1. Density

- High mortality
- Minimal mortality

2. Basal Area

3. Total Volume

4. Merchantable Volume

5-in Top D.o.b.
8-ft min. length
20 cm stump

MAI
15.4
14.3
12.2
10.5
7.1

MAI
14.1
10.5
6.9
2.a. Growth & Yield

- Thinning → direct growth to fewer stems and capture mortality
- QMD increases with initial spacing
- Thinning accelerates QMD development
- E.g. 2.1 m: 22, 28, 30, 35 cm

![Graphs showing QMD development with different initial spacings and light conditions.](image-url)
2.a. Growth & Yield

- Example: 25 cm target in 2.1 m spacing
  - NoThin: 60 yr
  - 37.9 & 32.1 BA: 50 yr
  - 25.3 BA: 43 yr
2.a. Growth & Yield

Merchantable Volume Production (5-in top D.o.b, 8-ft min. length, 20 cm stump)

- 2.1-3 m optimal initial spacing (>800 m³/ha)
- After last thinning:
  - Light ~ 435 m³/ha
  - Mod. ~ 350 m³/ha
  - Heavy 268 m³/ha
- 4.3 & 6.1 m under utilized growing space
- 2.1-3 m thinnings; too early, heavy, or rapid?
2.a. Growth & Yield

Cumulative Yield = total volume (standing + mortality + harvested); start 1982

- 1.2-1.8 m → parallel; capturing mortality
- 2.1-3.0 m → divergent; under utilized space
- Unthinned 1.2-3m: 840-950 m$^3$/ha
- Light: declining as spacing increases
- Mod.: ~750 m$^3$/ha
- Heavy: 683 m$^3$/ha
2.a. Growth & Yield

Take home messages...

1. Red Pine is very productive!!!
2. Initial spacing; no thinning
   a) 2.1-3 m minimized competition induced mortality and maximized basal area and volume production
   b) > 3 m increases individual tree size but sacrifices overall volume
   c) < 2.1 produces smaller trees and less merch. volume
3. Thinning accelerates individual tree growth and reduces time to operability
4. Cumulative Yield
   a) Unthinned: declines sharply after 3 m
   b) Thinned: declines with increasing spacing → 1st entry too early/heavy at lower densities
### 2.b. Products

Gradient of product value $\rightarrow$ poles $>$ sawlogs $>$ pulp &/or biomass

Product segregation:

<table>
<thead>
<tr>
<th>Product</th>
<th>Stump Ht.</th>
<th>Min. Length</th>
<th>Min. Top D.o.b.</th>
<th>Min. Circ. 6ft from base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poles (starting in 2012)</td>
<td>30 cm</td>
<td>42-ft small</td>
<td>8 in.</td>
<td>38 in.</td>
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<tr>
<td></td>
<td></td>
<td>42-ft big</td>
<td>8 in.</td>
<td>41 in.</td>
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<td></td>
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<td>47-ft</td>
<td>8 in.</td>
<td>43 in.</td>
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<td>52-ft</td>
<td>9 in.</td>
<td>48 in.</td>
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<td>57-ft</td>
<td>9 in.</td>
<td>50 in.</td>
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<td>62-ft</td>
<td>9 in.</td>
<td>52 in.</td>
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<td>67-ft</td>
<td>9 in.</td>
<td>54 in.</td>
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<tr>
<td></td>
<td></td>
<td>72-ft</td>
<td>9 in.</td>
<td>56 in.</td>
</tr>
<tr>
<td>Large Sawlogs</td>
<td>20 cm</td>
<td>8-ft or 16-ft in.</td>
<td>10 in.</td>
<td>-</td>
</tr>
<tr>
<td>Small Sawlogs</td>
<td>20 cm</td>
<td>8-ft</td>
<td>5 in.</td>
<td>-</td>
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<tr>
<td>Pulp</td>
<td>20 cm</td>
<td>8-ft</td>
<td>7 cm</td>
<td>-</td>
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<tr>
<td>Biomass</td>
<td>20 cm</td>
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</tbody>
</table>

Also, pole survey in 2013; every tree evaluated for current and future potential.

Segregation using taper function by Zakrewski and Penner (2013)
2.b. Products

Unthinned: Potential Harvest Products

1. Most volume in small sawlogs
2. Most pulp in narrow spacings
3. Sig. large sawlog production in 3 m by 40 years
4. Only poles in 3 m; 4.3 & 6.1 too branchy

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2. b. Products

Thinned: Estimated harvest product recovery

1. Most volume in small sawlogs

2. Pulp declines with age; lots in 1st & 2nd entry in narrowest spacings

3. Most large sawlogs at 60 yr in > 2.1 m; except 3 m and 2.1 heavy

4. Only poles in 3 m and 2.4 moderate
2.c. Products – a closer look at utility pole production

More with increase spacing and thinning intensity... up to a point

Predicted:
- Based on size
- Downgrades for forks and crooks

Pole Survey:
- Downgrades for knots and suppressed

Combined:
- Yes for predicted and pole survey

<table>
<thead>
<tr>
<th>BATarget (m²/ha)</th>
<th>1.2</th>
<th>1.5</th>
<th>1.8</th>
<th>2.1</th>
<th>2.4</th>
<th>3</th>
<th>4.3</th>
<th>6.1</th>
<th>Overall</th>
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<tbody>
<tr>
<td>Predicted</td>
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<td>65%</td>
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<td>32.1</td>
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<td>16% 16%</td>
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<td>37.9</td>
<td>17%</td>
<td>2%</td>
<td>5%</td>
<td>12%</td>
<td>44%</td>
<td>61%</td>
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<tr>
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<td>0%</td>
<td>2%</td>
<td>27%</td>
<td>78%</td>
<td>92%</td>
<td>17%</td>
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<tr>
<td>Pole Survey</td>
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<td>30% 47%</td>
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<td>37.9</td>
<td>13%</td>
<td>8%</td>
<td>6%</td>
<td>16%</td>
<td>29%</td>
<td>38%</td>
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<td>2%</td>
<td>4%</td>
<td>15%</td>
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<td>32.1</td>
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<td>37.9</td>
<td>7%</td>
<td>2%</td>
<td>3%</td>
<td>6%</td>
<td>20%</td>
<td>31%</td>
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<tr>
<td>NoThin</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
<td>8%</td>
<td>0%</td>
<td>0%</td>
<td>5%</td>
</tr>
</tbody>
</table>
2.c. Products – a closer look at utility pole production

Room to grow...

Proportion of Pole Sizes

<table>
<thead>
<tr>
<th>Pole Sizes</th>
<th>42 small</th>
<th>42 big</th>
<th>47-ft</th>
<th>52-ft</th>
<th>57-ft</th>
<th>62-ft</th>
<th>67-ft</th>
<th>72-ft</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>57%</td>
<td>27%</td>
<td>13%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

- Thinned: Many trees still to grow into poles, except in 2.1-heavy and 3-light
- Unthinned: limited potential

<table>
<thead>
<tr>
<th>Predicted Proportion of Stems Potentially Suitable for Utility Poles</th>
</tr>
</thead>
<tbody>
<tr>
<td>BATarget (m²/ha)</td>
</tr>
<tr>
<td>-----------------</td>
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<tr>
<td></td>
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<tr>
<td>25.3</td>
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<tr>
<td>32.1</td>
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<tr>
<td>37.9</td>
</tr>
<tr>
<td>NoThin</td>
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</tbody>
</table>
3. Economic Considerations

- Red pine is highly productive at any initial spacing → lots of volume from a small landbase
- 2.1 to 3 m spacing optimal → minimal mortality, highest production of valuable products, reasonable establishment costs

Thinning Offers:
- Potential to shorten time to tree size targets
- Earlier recovery of establishment investment
- Increased production of valuable products (poles and large sawlogs) and minimized low value products
- Lower $/unit harvest costs → fewer, larger stems cost less to harvest and process, especially at final harvest

Economic analysis required to identify optimal treatment
Thank you

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Thank you
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3: Red Pine Initial Spacing / Commercial Thinning Trial

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- QMD increases with initial spacing
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  E.g. 25 cm target in 2.1 m spacing
  NoThin: 60 yr
  37.9 & 32.1 BA: 50 yr
  25.3 BA: 43 yr
2.a. Growth & Yield

Cumulative Live Yield = total volume (standing + harvested); start 1982

- 1.2-1.8 m → not all mortality captured with thinning
- 2.1-3.0 m unthinned → yield maximized
- 2.1-3.0 m thinned → under utilized growing spacing
2.b. Products

Thinned: *Cumulative* Estimated harvest product recovery

1. Most volume in small sawlogs
2. Pulp declines with age; lots