Cut-to-Length Thinning in California’s Redwood Forests: Productivity, Cost, Soil Impacts, and Residual Stand Damage

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2, August 2017
Growing interest in redwood thinning using a CTL system...
Individual VS Clump
Cut-To-Length Method

Harvester

Forwarder
Study Objectives

✓ Determine productivity and cost of a CTL commercial thinning operation in redwood stands

✓ Evaluate soil impacts during winter CTL thinning operations.
  • bulk density (BD)

✓ Examine residual stand damage: individual vs. clump trees.
Study Area

- 10.1 ha on industrial timberland
- Watercourses and Lake Protection Zones (WLPZ)
- 25-30 years old trees commercially thinned
<table>
<thead>
<tr>
<th></th>
<th>Pre-Thinning</th>
<th>Post-Thinning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. DBH (cm)</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>Avg #stems/clump</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Avg. basal area (m²/ha)</td>
<td>99</td>
<td>40</td>
</tr>
<tr>
<td>Stand density (tph⁴)</td>
<td>2393</td>
<td>769</td>
</tr>
<tr>
<td>Species composition (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>redwood</td>
<td>77</td>
<td>79</td>
</tr>
<tr>
<td>red alder</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Douglas-fir</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Sitka spruce</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

⁴ trees (>5cm in DBH) per ha
Detailed Time and Motion Study

Felling/Processing Cycle
- brush
- fell
- move
- process
- top buck

Forwarding Cycle
- travel empty
- unload
- travel full
- arrangement
- travel loading
- load

Loading Cycle
- deck to truck
- bunk to truck
- arrangement
- move to deck
- deck to bunk

Delay Analysis
- mechanical
- operational
- personal
Data Collection: Bulk Density

Soil Core Sampler

Between tracks

Forwarding tracks

Reference
Data Collection: Stand Damage

- Removal of the bark down to cambial layer, exposing sapwood
- Systematic plot sampling
- Data collection
  - Number of trees damaged
  - Scar width and length
Results
### Stump-To-Truck Cost ($/m³)

<table>
<thead>
<tr>
<th></th>
<th>Machine Cost ($/PMH&lt;sup&gt;a&lt;/sup&gt;)</th>
<th>Hourly Production (m³/PMH)</th>
<th>Thinning Cost ($/m³)</th>
<th>Percent of Total Cost (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvester</td>
<td>230.9</td>
<td>27.7</td>
<td>8.3</td>
<td>42.4</td>
</tr>
<tr>
<td>Forwarder</td>
<td>183.6</td>
<td>22.4</td>
<td>8.2</td>
<td>41.7</td>
</tr>
<tr>
<td>Loader (Forwarder)</td>
<td>183.6</td>
<td>58.9</td>
<td>3.1</td>
<td>15.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>598.1</strong></td>
<td><strong>19.7</strong></td>
<td></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

<sup>a</sup>productive machine hour
<table>
<thead>
<tr>
<th>Soil depth (cm)</th>
<th>BD on the track (g/cm³)</th>
<th>BD Desirable (g/cm³)</th>
<th>BD affecting root growth (g/cm³)</th>
<th>BD restricting root growth (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>0.83</td>
<td>&lt;1.30</td>
<td>1.60</td>
<td>&gt;1.75</td>
</tr>
<tr>
<td>10-15</td>
<td>1.08</td>
<td>&lt;1.40</td>
<td>1.55</td>
<td>&gt;1.65</td>
</tr>
<tr>
<td>20-25</td>
<td>1.13</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Pierce et al. (1983)*
### Scar Size and % Damage

<table>
<thead>
<tr>
<th>Scar width</th>
<th>Scar length</th>
<th>p-value*</th>
<th>Minimum scar width (cm)</th>
<th>% of damaged trees (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual (cm)</td>
<td>Clump (cm)</td>
<td>Individual (cm)</td>
<td>Clump (cm)</td>
<td>p-value*</td>
</tr>
<tr>
<td>8.1</td>
<td>9.1</td>
<td>0.1611</td>
<td>16.7</td>
<td>28.1</td>
</tr>
</tbody>
</table>

- Fungal decay is better correlated with scar width rather than length (Wallis and Morrison, 1975).
- Scars less than 10cm in width were closed within 10 years with no decay developed. (Han and Kellogg, 2000).
Conclusion

• The cost of thinning young redwood stands using a CTL system was comparable, as observed in other conifer stands.

• Productivity of CTL thinning in redwood forest was affected by tree type (individual vs. clump).

• Soil bulk density was increased, but the severity of soil compaction was not detrimental to tree growth.

• The amount of damage (>10cm in scar width) to residual trees was 7.6%.

⇒ Winter thinning of redwood forests using a CTL system appears to be operationally feasible.
Questions?
Water Infiltration Rate (WIR)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Soil depth (cm)</th>
<th>Reference</th>
<th>Center</th>
<th>Track</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>WIR (cm/hr)</td>
<td>0-5</td>
<td>1.25±1.48a</td>
<td>1.87±2.78a</td>
<td>1.17±1.43a</td>
<td>0.6579</td>
</tr>
</tbody>
</table>

- An increase in bulk density did not always associate with a significant decrease in water infiltration (Aust et al. 1992).

- The lack of forest residues and bare soil by high intensity rainfalls are factors of soil erosion (Franzluebbers 2001).
Data Collection: Water Infiltration Rate

mini-disc infiltrometer