Bunching stems in steep slopes for efficient yarder extraction

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Outline

• Technology in steep terrain
• Objectives and study layout
• Equipment and data collection
• Results Feller buncher
• Results Swing yarder
• Conclusions
Technology in steep terrain
Technology in steep terrain

(Amishev & Evanson 2010)
Trial objectives

- Analyse productivity and costs of a self-levelling feller buncher and swing yarder related to operational factors
- Investigate the effect of pre-bunching on the extraction phase
- Develop production and cost predictive equations
Study area
Study layout

Unbunched trees

Bunched trees

Feller Buncher plot

Swing Yarder plot
Equipment and data collection

Valmet 445 EXL

Madill 124
Results - Feller buncher

Mean time per tree (secs)

- Move-to-tree: 6.1 sec (29%)
- Swing-to-fell: 3.5 sec (17%)
- Swing-to-bunch: 6.6 sec (32%)
- Cut: 2.5 sec (12%)
- Second cut: 0.4 sec (2%)
- Second cut, Cut stump: 0.4 sec (2%)
- Fell and bunch dead trees: 0.3 sec (1%)
- Adjust bunch: 1.1 sec (5%)
- Travel: 0.4 sec (2%)

Total = 20.9 sec/tree

**Move-to-tree, Re-position:** Machine moving uphill in a straight line between successive tree felling and bunching activities, or machine movement laterally, adjusting the move-to-tree line.

**Swing-to-fell:** Machine slewing and extending the boom to position the felling head to fell a tree.

**Cut:** Saw operation to fell the tree.

**Swing-to-bunch:** Slewing the felled tree and lower to the ground or onto a bunch.

**Second cut, Cut stump:** A second extension of the saw to sever a tree not felled after the first cut, or a cut to lower the height of a stump.

**Fell and bunch dead trees:** Slewing, cutting and bunching or disposing of a dead tree.

**Adjust bunch:** Move trees in a bunch to reduce spread of the butts.

**Travel:** Machine movement (downhill) from the end of a felling swath to the start of the next.
Effect of diameter on cutting time

- Results - Feller buncher

**Effect of diameter on cutting time**

**Graph:**
- Linear relationship between DBH class (cm) and cut time (sec).
- Equation: $y = 0.5339e^{0.0534x}$
- $R^2 = 0.7322$

**Table:**

<table>
<thead>
<tr>
<th>Tree diameter class</th>
<th>Mean Cut time (sec)</th>
<th>Significant difference*</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>1.67</td>
<td>a</td>
</tr>
<tr>
<td>22</td>
<td>1.78</td>
<td>a</td>
</tr>
<tr>
<td>27</td>
<td>2.29</td>
<td>b</td>
</tr>
<tr>
<td>32</td>
<td>3.21</td>
<td>c</td>
</tr>
<tr>
<td>37</td>
<td>3.81</td>
<td>d</td>
</tr>
<tr>
<td>42</td>
<td>4.77</td>
<td>e</td>
</tr>
<tr>
<td>47+</td>
<td>6.36</td>
<td>f</td>
</tr>
</tbody>
</table>

* (Values with the same letter are not significantly different at $p > 0.05$)
Results - Feller buncher

Cycle time and productivity curves

[Graph showing productivity and cycles per PMH against piece size in m³.]
Results - Swing yarder

Mean time per cycle (min) - Bunched wood

- Swing-to-outhaul: 0.31, 15%
- Outhaul: 0.34, 17%
- Inhaul: 0.59, 29%
- Drop/hook: 0.81, 39%

Mean time per cycle (min) - Unbunched wood

- Swing-to-outhaul: 0.30, 14%
- Outhaul: 0.38, 18%
- Inhaul: 0.66, 30%
- Drop/hook: 0.82, 38%

Total = 2.05 min/cycle

Total = 2.18 min/cycle

**Swing-to-outhaul**: Yarder swing after dropping a load at the landing chute and is ready to start a new outhaul.

**Outhaul**: Grapple movement downhill (empty) until it is lowered down to get a load.

**Inhaul**: Grapple movement uphill with a load of logs until the load is dropped at the landing chute.

**Drop/hook**: Grapple descending towards the ground until the logs have been secured and the grapple starts moving up towards the landing.
Results - Swing yarder

Pieces per cycle

- Bunched wood
- Unbunched wood
# Results - Swing yarder

Performance measurements for a haul distance of 180 m

<table>
<thead>
<tr>
<th>Performance measurements</th>
<th>Bunched wood</th>
<th>Unbunched wood*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed haul cycles</td>
<td>142</td>
<td>42</td>
</tr>
<tr>
<td>Average pieces per cycle</td>
<td>2.3</td>
<td>1.5</td>
</tr>
<tr>
<td>Average pieces per PMH</td>
<td>68.1</td>
<td>41.6</td>
</tr>
<tr>
<td>Average time per cycle (min.)</td>
<td>2.7</td>
<td>2.3</td>
</tr>
<tr>
<td>Cycles per PMH</td>
<td>21.9</td>
<td>26.1</td>
</tr>
<tr>
<td>Average volume per cycle** (m³)</td>
<td>1.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Average volume per PMH (m³)</td>
<td>41.6</td>
<td>33.9</td>
</tr>
</tbody>
</table>

* All unbunched wood was manually felled

** Based on an average piece size of 0.81 m³ for the bunched wood and 0.87 m³ for the unbunched wood
Results - Swing yarder

Productivity curves

- Bunched wood
- Unbunched wood

Yarding distance (m)

Productivity (m³/PMH)
Results - Swing yarder

Effect of yarding distance and pieces per cycle
Conclusions

• In good clearfell conditions in steep terrain a tracked self-levelling feller buncher can achieve a high rate of productivity
• Bunching the trees increased the productivity of the swing yarder by 25% (19% reduction in costs)
• Mechanized felling improves safety and value recovery
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