Observations on the effects of rough-delimbing and load compression on harvesting system costs in fuel wood thinning

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First Thinning for fuel wood

Common Harvesting System in Sweden

- Thinning harvester with accumulating harvester/felling head
  - 60% of system cost

- Medium Sized Forwarder
  - 40% of system cost (@ 200 m)
  - (it is only 15% in pulpwood)
Small trees are bulky

Harvesting whole trees with Dbh of 6-8 cm

- In piled small trees only 25-35% of the bulk volume is solid mass
- 30-60% of the forwarder’s load capacity is normally used
Restrictions of the Work Environment

- Strip roads should be kept narrow and damages on remaining trees avoided
  - It is not possible to use a forwarder with a larger load space
  - Loading is complicated if tree sections exceed 7-8 m
  - With longer tree sections the forwarder is tail-heavy and difficult to maneuver
Aim of the study

Assess the technical and economic efficiency of systems including “rough-delimbing” and “load compression”.

Compared to unprocessed/un-compacted whole tree parts

- Field studies observations on time consumption and load densities
- Literature relations for bulk densities
- Follow-up data on system delays and costs

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Field studies

**System 1**
- Accumulating Felling Head *(No delimbing)*
- Medium sized forwarder *(No compaction)*

**System 2**
- Single Grip Harvester Head *(Rough delimbing)*
- Medium sized forwarder *(No compaction)*
System 1 [No compress/process] (18 loads)
Load Bulk Density = 207 kg/m³
Load Fresh Mass = 5.39 t (2.86 OD t)

45%

Factors
- Dbh = 6.7 cm
- Pile size = 151 kg
- Bucking length = 5.8 m

Load Capacity (12 t)

System 2 [Rough deliming] (17 loads)
Load Bulk Density = 296 kg/m³
Load Fresh Mass = 7.19 t (3.81 OD t)

60%

Factors
- Dbh = 7.6 cm
- Pile size = 365 kg
- Bucking length = 5.4 m

Load Capacity (12 t)
## System Economy

Reference systems based on bulk density curves from the literature (Bergström et al. 2010)

<table>
<thead>
<tr>
<th></th>
<th>S 1 field study</th>
<th>S1 + load compaction</th>
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</thead>
<tbody>
<tr>
<td><strong>Harvester productivity [od t/PW hour]</strong></td>
<td>2.84</td>
<td>2.84</td>
</tr>
<tr>
<td><strong>Forwarder productivity [od t/PW hour]</strong></td>
<td>4.86</td>
<td>5.61</td>
</tr>
<tr>
<td><strong>Harvesting cost [€/od t]</strong></td>
<td>33.53</td>
<td>33.53</td>
</tr>
<tr>
<td><strong>Forwarding cost [€/od t]</strong></td>
<td>16.83</td>
<td>14.51</td>
</tr>
<tr>
<td><strong>Total cost [€/od t]</strong></td>
<td><strong>50.36</strong></td>
<td><strong>48.04</strong></td>
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<table>
<thead>
<tr>
<th></th>
<th>S 2 field study</th>
<th>S2 - rough delimming</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Harvester productivity [od t/PW hour]</strong></td>
<td>2.94</td>
<td>3.23</td>
</tr>
<tr>
<td><strong>Forwarder productivity [od t/PW hour]</strong></td>
<td>6.45</td>
<td>3.72</td>
</tr>
<tr>
<td><strong>Harvesting cost [€/od t]</strong></td>
<td>32.39</td>
<td>29.45</td>
</tr>
<tr>
<td><strong>Forwarding cost [€/od t]</strong></td>
<td>12.63</td>
<td>21.89</td>
</tr>
<tr>
<td><strong>Total cost [€/od t]</strong></td>
<td><strong>45.02</strong></td>
<td><strong>51.33</strong></td>
</tr>
</tbody>
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- Load Compaction: - 5% of total cost
- Rough Delimbing: - 12% of total cost
Some Considerations

The single-grip harvester in S2 had limited capacity for accumulating small trees:
- an accumulating function should be used

If the harvested Dbh exceeds 8 cm:
- Feed-rollers can double the compaction effect

Bucking length affects the payload and productivity
- tree parts should be as long as possible

Grapple-saw on the forwarder?
- Productivity of the forwarder while loading
- Productivity of the harvester while felling-bunching

To reduce system costs by 10% We can use a 45% increase in bulk density by load compaction

Compressing devices should cost max. 7% of a 15 t forwarder purchase price (e.g. €16,000 on €230,000)

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The alternative could be bundling...but...

It should be based on simple solutions to remain cost efficient!
Conclusions

- Rough-deliming and load compression can increase the harvesting efficiency in fuel-wood thinnings.

- The compressing solutions should be simple in order to remain “cheap”.

- Future development and optimization of cost-effective compressing and bundling equipment could allow early thinnings to be more profitable than present.
Thanks for your attention!

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