MONITORING THE DRYING OF RESIDUE BUNDLES DURING STORAGE IN THE FOREST AND AT A TERMINAL IN IRELAND

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Objectives of the Trial

Pre-commercial determination of:

• Rate of MC% change storing at a terminal and in the forest;
• Variation in drying between green & brown bundles;
• Effect of covering bundles in stack;
• Effect of stacking in double width rows compared to single width rows;
• Effect on drying of exposure on an open clearfell site compared to storage under trees at a sheltered site.
Trial Overview

• 1100 bundles made from Sitka spruce (*Picea sitchensis*) residues of shortwood clearfell operations.

• Roundwood cut to 7cm top diameter.

• All bundles were 70cm in diameter and 2.5m length.

• Brown residues: site clearfelled in May 2009; harvester and forwarder drove on residues; left loose over winter & bundled in February 2010.

• Green residues: Clearfell in February 2010, bundled within 4 weeks.

• Storage trials from March to August 2010.
## Methods: Forest Storage Treatments

<table>
<thead>
<tr>
<th>Storage Treatments</th>
<th>Green</th>
<th>Brown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top Cover</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>No Cover</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Stacking:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Row</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Double Row</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Site:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposed</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sheltered</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Green bundles, exposed site, single row, covered and no cover
Brown bundles, exposed site, single row, covered and no cover
Brown bundles, double row, exposed site, cover and no cover
Brown bundles, single row, in sheltered site with no cover and cover
Methods: Storage at Terminal

• 125 green and 125 brown bundles placed in six storage bins on load cells
• Monitored weight change continuously over time

Treatments trialed:
• Green bundles with a top cover, replicated in two bins
• Green bundles with no top cover, no replication
• Brown bundles with a top cover, replicated in two bins
• Brown bundles with no top cover, no replication
Top covered & uncovered bundles in storage bins on load cells at terminal
Moisture content sampling

Pre-storage:
• Total weight of each stack
• 90 green & 63 brown bundles sampled

Post-storage:
• Total weight of each stack
• Forest storage trial: 20 bundles per stack, 160 bundles in total
• Terminal storage: 50 point samples per storage bin, 300 samples in total
• Moisture content determined by oven drying to 105°C
• All bundles comminuted with Jenz 660AZ chipper/shredder
Sampling bundles for moisture at the terminal
Weather Conditions

![Graph showing monthly rainfall and temperature comparison with 30-year mean values.](image)
## Results: Forest Storage Trial

<table>
<thead>
<tr>
<th>Stack ID</th>
<th>No. Bundle</th>
<th>Storage Period</th>
<th>Pre Storage Total Wt.</th>
<th>Post Storage Total Wt</th>
<th>Pre-storage Moisture</th>
<th>Post-storage Moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>G</td>
<td>N</td>
<td>S</td>
<td>EX</td>
<td>120</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>G</td>
<td>C</td>
<td>S</td>
<td>EX</td>
<td>119</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>N</td>
<td>S</td>
<td>EX</td>
<td>49</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>C</td>
<td>S</td>
<td>EX</td>
<td>140</td>
<td>21</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>N</td>
<td>S</td>
<td>SH</td>
<td>71</td>
<td>21</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>C</td>
<td>S</td>
<td>SH</td>
<td>184</td>
<td>21</td>
</tr>
<tr>
<td>7</td>
<td>B</td>
<td>N</td>
<td>D</td>
<td>EX</td>
<td>104</td>
<td>21</td>
</tr>
<tr>
<td>8</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>EX</td>
<td>70</td>
<td>21</td>
</tr>
</tbody>
</table>

( ) standard deviation
Forest Storage Results: Effect Of Top Cover On Drying In Green And Brown Bundles

![Bar chart showing the effect of top cover on drying in green and brown bundles. The x-axis represents the bundles (green and brown), and the y-axis represents the percentage of total weight (M, % total wt.). The chart includes bars for 'Pre-storage', 'No cover', and 'Cover'.]
Forest Storage Results: Effect Of Stacking Bundles In Single Or Double Rows

![Graph showing the effect of stacking bundles in single or double rows on the percentage of total weight (M) for uncovered and covered brown. The graph compares pre-storage, single width, and double width conditions.]
Forest Storage Results: Effect Of Stacking in Exposed or Sheltered location

![Bar Chart]

- M, % total wt.
- Uncovered Brown
- Covered Brown
- Pre-storage, Exposed, Sheltered

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## Results: Terminal Storage

<table>
<thead>
<tr>
<th>Stack ID</th>
<th>Storage Period [weeks]</th>
<th>Start Weight [kg]</th>
<th>End Weight [kg]</th>
<th>End Moisture Content [% total wt.]</th>
<th>End Dry Matter Wt. [kg]</th>
<th>Start Moisture Content [% total wt.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>G C 19</td>
<td>13688</td>
<td>8196</td>
<td>25.1 (3.6)</td>
<td>6139</td>
<td>55</td>
</tr>
<tr>
<td>2</td>
<td>G N 19</td>
<td>12815</td>
<td>7782</td>
<td>23.3 (2.9)</td>
<td>5969</td>
<td>53</td>
</tr>
<tr>
<td>3</td>
<td>G C 19</td>
<td>14858</td>
<td>8729</td>
<td>24.2 (2.3)</td>
<td>6617</td>
<td>55</td>
</tr>
<tr>
<td>4</td>
<td>B C 21</td>
<td>15146</td>
<td>9864</td>
<td>32.4 (5.6)</td>
<td>6668</td>
<td>56</td>
</tr>
<tr>
<td>5</td>
<td>B N 19</td>
<td>16513</td>
<td>10545</td>
<td>31.2 (6.1)</td>
<td>7255</td>
<td>56</td>
</tr>
<tr>
<td>6</td>
<td>B C 19</td>
<td>14978</td>
<td>9625</td>
<td>28.8 (4.7)</td>
<td>6853</td>
<td>54</td>
</tr>
</tbody>
</table>
Terminal Storage Results: Stack Weight Change Over Storage Period At Terminal

![Graph showing stack weight change over time for different storage conditions]
Terminal Storage Results: Moisture Content Change Over Storage Period At Terminal

- Green Covered
- Green No Cover
- Green Cover 2
- Brown Cover
- Brown No Cover
- Brown Cover 2

45mm rain on 8th June
100mm rain in 1 week
Conclusions: forest storage of residue bundles

• Green & brown bundles dried significantly over storage period – benefit for transport & energy content

• Using a top cover improved drying in green bundles but not (statistically significantly) in brown bundles

• Stacking in a double row did not significantly affect drying – benefit for extraction and storage space

• No (statistically significant) difference between exposed and sheltered locations

• Variation in bundles within stack was a confounding effect.
Variation in bundle composition

woody bundles dried better than bundles with high fine branch/needle content
Conclusions: Storage at Terminal

• Better and more uniform drying compared to forest storage - No ground contact

• Top cover had no significant effect, contrary to forest storage

• Moisture content may increase during heavy rainfall, but effect is temporary.

• Recommendation: Delay removal/chipping for two weeks after heavy rain

• Overall recommendation: Preparation for bundling during harvesting necessary to increase quality uniformity
Acknowledgements

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Thank you.