Measuring Pulp Logs and Biomass: results of log studies

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UNECE/FAO Timber Section

Timber Measurements Society
Coeur d’Alene Idaho, April 11-13, 2012
Measuring pulp logs and biomass

- What does the purchaser want?
  - An accurate predictor of useable fiber

- What are our options for measuring?
  - Green weight
  - Dry weight
  - Solid volume
  - Bulk volume
    - Chips (units or loose volume)
    - Logs (stacked volume, e.g., cords)
  - Board feet
Dry weight review (purchaser’s favorite)

- **Bone-dry weight**
  - The weight of fiber with all of the moisture removed
  - Normal procedure is to establish the weight in the green-state; take a representative sample of fiber, weight it green, dry it in an oven at (+ or –) 217 degrees until weight stabilizes; divide bone-dry weight by green weight and multiply ratio times total weight.

Douglas fir

Grand fir
Units of measure for biomass

- Bone dry unit (BDU) = 2,400 lbs dry or 1088.4 kg
- Bone dry tonne (BDMT) = 2,205 lbs dry or 1,000 kg
- Bone dry ton (BDT) = 2,000 lbs dry or 907 kg
Dry weight review (example)

Net weight = 71,000 lbs or 32,200 kg

<table>
<thead>
<tr>
<th>Green chip sample</th>
<th>Bone-dry sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>922 g</td>
<td>497 g</td>
</tr>
</tbody>
</table>

\[
\begin{align*}
497 \div 922 &= 53.9\% \text{ fiber} \\
.539 \times 71,000 &= 38,269 \text{ lbs} \\
\text{or } &\times 32,200 \text{ kg} = 17,356 \text{ kg}
\end{align*}
\]

- Bone dry Unit: \(38,269 \div 2,400 = 15.945 \text{ BDU}\)
- Bone-dry ton: \(38,269 \div 2,000 = 19.135 \text{ BDT}\)

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Specific gravity and basic density

- Specific gravity = the ratio of weight of a given volume relative to the weight of the same volume of water
- For our purposes here, SG always refers to green volume (before shrinkage) and dry weight
- Water weighs 62.4 lbs/ft\(^3\) (1,000 kg/m\(^3\))
- Basic density is the weight for a cubic meter (for our purposes, always dry), i.e., SG x 1,000
- Example: wood or bark with an SG of 0.50 would have 31.2 lbs/ft\(^3\) or 500 kg/m\(^3\) of dry fiber
Example of 0.45 SG and basic density of 450 kg

One m³ green wood dry weight is 450 kg

One m³ H₂O 1,000 kg

One ft³ gr. wood dry wt 28.1 lb

One ft³ H₂O 62.4 lbs

= 0.45

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## Western Species wood and bark properties

<table>
<thead>
<tr>
<th>Common name</th>
<th>Latin name</th>
<th>Wood lbs/ft³</th>
<th>Wood Specific Gravity (green m³)</th>
<th>Wood heating value BTU/lb</th>
<th>Wood gigajoules per tonne</th>
<th>Bark % log weight (bark &amp; wood)</th>
<th>Bark % log wood volume</th>
<th>Bark lbs/ft³</th>
<th>Bark Specific Gravity (green m³)</th>
<th>Bark heating value BTU/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conifers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Grand fir</td>
<td><em>Abies grandis</em></td>
<td>48.8</td>
<td>0.35</td>
<td>8150</td>
<td>18.99</td>
<td>11.7</td>
<td>14.3</td>
<td>45.1</td>
<td>0.54</td>
<td>--</td>
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<tr>
<td>Subalpine fir</td>
<td><em>Abies lasiocarpa</em></td>
<td>39.9</td>
<td>0.31</td>
<td>--</td>
<td>--</td>
<td>15.5</td>
<td>15.7</td>
<td>46.7</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Western larch</td>
<td><em>Larix occidentalis</em></td>
<td>51.7</td>
<td>0.48</td>
<td>--</td>
<td>--</td>
<td>10.1</td>
<td>19.5</td>
<td>29.9</td>
<td>0.44</td>
<td>8750</td>
</tr>
<tr>
<td>Engelmann spruce</td>
<td><em>Picea engelmannii</em></td>
<td>51.5</td>
<td>0.33</td>
<td>--</td>
<td>--</td>
<td>11.0</td>
<td>13.0</td>
<td>48.8</td>
<td>0.48</td>
<td>8820</td>
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<tr>
<td>White spruce</td>
<td><em>Picea Glauc</em>a</td>
<td>46.2</td>
<td>0.37</td>
<td>--</td>
<td>--</td>
<td>7.3</td>
<td>10.0</td>
<td>36.0</td>
<td>0.29</td>
<td>8530</td>
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<tr>
<td>Lodgepole pine</td>
<td><em>Pinus contorta</em></td>
<td>53.5</td>
<td>0.38</td>
<td>8600</td>
<td>20.04</td>
<td>5.4</td>
<td>6.0</td>
<td>50.7</td>
<td>0.46</td>
<td>9382</td>
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<tr>
<td>Western white pine</td>
<td><em>Pinus monticola</em></td>
<td>46.1</td>
<td>0.35</td>
<td>9610</td>
<td>22.39</td>
<td>12.4</td>
<td>0.0</td>
<td>43.5</td>
<td>0.49</td>
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<tr>
<td>Ponderosa pine</td>
<td><em>Pinus ponderosa</em></td>
<td>56.0</td>
<td>0.38</td>
<td>9120</td>
<td>21.25</td>
<td>11.7</td>
<td>20.3</td>
<td>33.6</td>
<td>0.34</td>
<td>9616</td>
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<tr>
<td>Douglas fir</td>
<td><em>Pseudotsuga menziesii</em></td>
<td>51.2</td>
<td>0.45</td>
<td>8910</td>
<td>20.76</td>
<td>13.7</td>
<td>20.1</td>
<td>40.5</td>
<td>0.44</td>
<td>9962</td>
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<tr>
<td>Western red cedar</td>
<td><em>Thuja plicata</em></td>
<td>34.2</td>
<td>0.31</td>
<td>9700</td>
<td>22.60</td>
<td>11.8</td>
<td>12.6</td>
<td>36.2</td>
<td>0.37</td>
<td>8700</td>
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<tr>
<td>Western hemlock</td>
<td><em>Tsuga heterophylla</em></td>
<td>53.5</td>
<td>0.42</td>
<td>--</td>
<td>--</td>
<td>9.2</td>
<td>10.3</td>
<td>52.6</td>
<td>0.50</td>
<td>9297</td>
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<tr>
<td>Mountain hemlock</td>
<td><em>Tsuga mertensiana</em></td>
<td>56.9</td>
<td>0.42</td>
<td>--</td>
<td>--</td>
<td>15.0</td>
<td>25.1</td>
<td>40.0</td>
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<td>--</td>
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</tbody>
</table>
# Approximate raw material to product ratios

<table>
<thead>
<tr>
<th>Composite panels</th>
<th>Inputted wood units per one product output unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ft³/ft³</td>
</tr>
<tr>
<td>Insulation board</td>
<td>0.66</td>
</tr>
<tr>
<td>Particleboard</td>
<td>1.32</td>
</tr>
<tr>
<td>MDF</td>
<td>1.73</td>
</tr>
<tr>
<td>OSB</td>
<td>1.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pulp yields</th>
<th>Wood/pulp</th>
<th>Wood/pulp</th>
<th>Wood/pulp</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ft³/BDT</td>
<td>m³/BDMT</td>
<td>BDT/BDT</td>
</tr>
<tr>
<td>Mechanical paper</td>
<td>84.3</td>
<td>2.63</td>
<td>1.05</td>
</tr>
<tr>
<td>Chemi-mechanical process</td>
<td>89</td>
<td>2.78</td>
<td>1.11</td>
</tr>
<tr>
<td>Kraft paper (bleached)</td>
<td>186.3</td>
<td>5.82</td>
<td>2.33</td>
</tr>
<tr>
<td>Kraft paper (unbleached)</td>
<td>157.1</td>
<td>4.9</td>
<td>1.96</td>
</tr>
</tbody>
</table>

Assumes inputted wood fiber SG of 0.40
Log Tests

- **Bull frog chip plant (Cle Elum WA, early Fall, 1991)**
  - Stationary chipper
  - All chips screened
  - Mostly bigger logs not suitable for sawlogs (cull), except for ponderosa pine thinning sort
  - Logs, weighed, corded, scaled in Scribner (east-side and cubic)

- **Pablo MT, Summer 1998**
  - Portable chain flail chipper
  - No Screening of chips
  - All thinning logs and tops
  - Logs weighed and scaled cubic
Test logs summary

<table>
<thead>
<tr>
<th>CATAGORY</th>
<th>Delivered Tons</th>
<th>Delivered CORDS</th>
<th>Delivered MBF</th>
<th>Delivered CF</th>
<th>Delivered m3</th>
<th>Delivered BDT Chips</th>
</tr>
</thead>
<tbody>
<tr>
<td>20&quot;+ hem - fir</td>
<td>169.74</td>
<td>76.40</td>
<td>46.93</td>
<td>6455.2</td>
<td>182.8</td>
<td>74.63</td>
</tr>
<tr>
<td>6&quot;-19&quot; hem - fir</td>
<td>227.35</td>
<td>111.50</td>
<td>49.21</td>
<td>8760.8</td>
<td>248.1</td>
<td>116.20</td>
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<tr>
<td>3&quot;-5&quot; Ponderosa</td>
<td>79.04</td>
<td>33.70</td>
<td>9.11</td>
<td>2359.0</td>
<td>66.8</td>
<td>30.98</td>
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<tr>
<td>6&quot;-19&quot; DF/L</td>
<td>174.98</td>
<td>87.90</td>
<td>35.43</td>
<td>6102.9</td>
<td>172.8</td>
<td>97.38</td>
</tr>
<tr>
<td>20&quot;+ DF/L</td>
<td>47.35</td>
<td>23.10</td>
<td>11.66</td>
<td>1621.3</td>
<td>45.9</td>
<td>24.36</td>
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<tr>
<td>3-5&quot; top LPP</td>
<td>28.17</td>
<td></td>
<td></td>
<td>1015.5</td>
<td>28.8</td>
<td>15.00</td>
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<tr>
<td>3-5&quot; Hem/GF/L</td>
<td>25.97</td>
<td></td>
<td></td>
<td>842.8</td>
<td>23.9</td>
<td>11.93</td>
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<tr>
<td>3-5&quot; PP</td>
<td>27.86</td>
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<td>861.6</td>
<td>24.4</td>
<td>12.07</td>
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<tr>
<td>3-5&quot; DF</td>
<td>23.83</td>
<td></td>
<td></td>
<td>707.5</td>
<td>20.0</td>
<td>11.80</td>
</tr>
</tbody>
</table>
Fiber yield related to delivered weight

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Delivered tons per BDT

Delivered tons/BDT

Total
3-5" DF
3-5" PP
3-5" Hem/GF/L
3-5" LPP
20"+ DF/L
6"-19" DF/L
3"-5" Ponderosa
6"-19" hem - fir
20"+ hem - fir

CV = 12%

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Delivered tons per BDU

Delivered tons/BDU

- Total
- 3-5" DF
- 3-5" PP
- 3-5" Hem/GF/L
- 3-5" LPP
- 20"+ DF/L
- 6"-19" DF/L
- 3"-5" Ponderosa
- 6"-19" hem - fir
- 20"+ hem - fir

CV = 12%

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ft³ log scale per BDT

CV = 11%

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Coeur d’Alene Idaho, April 11-13, 2012
$m^3$ log scale per BDT

CV = 11%

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Cords per BDT

Cords/BDT

Total

20"+ DF/L

6"-19" DF/L

3"-5" Ponderosa

6"-19" hem - fir

20"+ hem - fir

CV = 7%
MBF (East-side) per BDT

CV = 29%

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Cubic plus published SG by species

(Log volume in m³ x published SG x (2205 ÷ 2000)) ÷ BDT actual chip yield

**Note:** SG used were: DF = 0.45, LPP and PP = 0.38, hem-fir = 0.35

CV = 6%

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Log test conclusions

- Not advisable to use Scribner to measure pulp logs!
- Cords, cubic and green tons all are much better predictors of recovery
- Cubic coupled with average SG would be the best, e.g., 100 m$^3$ of DF logs (3,513 ft$^3$), (SG 0.45) = 45 BDT
- About 2 tons of logs = 1 BDT; 2.4 tons of logs = 1 BDU (+ or – for inland NW USA)
- A cord is roughly the equivalent of a BDT
- Roughly 15% of the delivered weight ends up as hogfuel (flails and debarkers also remove some wood with bark).
Is there another way? Ask the Austrians

Sample Taking

- Lorry: 10 samples of truck vehicle and 10 samples of trailer
- Cutting along one line within the allowed sector
- Snow cover has to be removed in prior of sample taking
Chainsaw sampler

Chain saw with saw dust catching device