Production of Quality Feedstock from Forest Residues

Han-Sup Han*, Anil Kizha, Joel Bisson, and Heesung Woo
*Professor/Director, Forest Operations and Biomass Utilization
Ecological Restoration Institute
Northern Arizona University
Flagstaff, Arizona, USA

www.nau.edu/eri
Grinding
Particle Size Distribution

- <1 cm
- 1 - 2 cm
- 2 - 5 cm
- 5 - 8 cm
- >8 cm
## Feedstock Quality – Biomass Conversion Techs

<table>
<thead>
<tr>
<th>Biomass Conversion Technology</th>
<th>Product</th>
<th>Desired feedstock specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Particle size (cm)</td>
</tr>
<tr>
<td>Gasification</td>
<td>Biochar</td>
<td>0.25 - 10.00</td>
</tr>
<tr>
<td>Torrefaction</td>
<td>Torrefied chips</td>
<td>0.25 – 2.50</td>
</tr>
<tr>
<td>Densification</td>
<td>Briquettes</td>
<td>&lt; 5.00</td>
</tr>
</tbody>
</table>

(Schatz Energy Research Center, 2017)
Current practice

Sorting tree tops

Sawlogs

Forest residues

Processed tops

Slash piles
Sorting tree tops during timber harvesting
Various types of feedstock produced from forest residues

- **wood chips** (<1.9 cm)
- **micro-chips** (<0.6 cm)
- **sawdust** (<0.3 cm)
On-site Moisture Content Reduction

Processor piled

Criss-cross

Teepee

Scattered
Moisture Content Changes
Key messages...

✓ Sorting stem wood and tree tops from other residues during a timber harvest operation facilitates the use of a chipper.

✓ Through sorting and chipping of forest residues, we were able to produce various types (wood chips, micro-chips, and sawdust) of quality feedstock.

✓ We can lower moisture content by making different types of biomass pile arrangement.
Thank You!

http://wastetowisdom.com/
# Machine Performance

<table>
<thead>
<tr>
<th>Machine type</th>
<th>Horsepower</th>
<th>Productivity (metric tons/PMH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morbark 30 disc chipper</td>
<td>875</td>
<td>38</td>
</tr>
<tr>
<td>Peterson Pacific 4300B drum micro-chipper</td>
<td>765</td>
<td>41</td>
</tr>
<tr>
<td>Nelson Sawdust Chipper</td>
<td>400</td>
<td>18</td>
</tr>
</tbody>
</table>

PMH: productive machine hour
Production of quality feedstock from forest residues

• Size distribution:
  • Chipped materials (tree tops): >95% chips less than 5 cm
  • Ground materials (slash): >55% hogged materials larger than 5 cm

<table>
<thead>
<tr>
<th>Material type</th>
<th>Average length (cm)</th>
<th>Bulk density (kg/m^3)</th>
<th>Ash content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processed tops (conifer)</td>
<td>1.7</td>
<td>228</td>
<td>0.27</td>
</tr>
<tr>
<td>Processed tops (hardwood)</td>
<td>1.8</td>
<td>322</td>
<td>1.03</td>
</tr>
<tr>
<td>Slash</td>
<td>4.7</td>
<td>137</td>
<td>1.50</td>
</tr>
<tr>
<td>Unprocessed tops (conifer)</td>
<td>1.8</td>
<td>239</td>
<td>0.64</td>
</tr>
<tr>
<td>Unprocessed tops (hardwood)</td>
<td>2.1</td>
<td>309</td>
<td>1.07</td>
</tr>
</tbody>
</table>

Chipped Materials

Ground Materials
In-woods Biomass Conversion:

- Decrease transportation and handling costs
- Increase product values