Estimating logging residue volumes in the state of Idaho: preliminary predictive models

Erik Berg\textsuperscript{a}, Eric Simmons\textsuperscript{a}, Stan Zarnoch\textsuperscript{b}, Todd Morgan\textsuperscript{a}, Steve Hayes\textsuperscript{a}, Charles Gale\textsuperscript{a}

\textsuperscript{a}Bureau of Business and Economic Research, University of Montana

\textsuperscript{b}USDA Forest Service Southern Research Station
The need: Land managers seek to quantify the amount of woody residue left on-site after logging

- Residue info. uses
  - Biomass for energy production
  - Nutrient recycling
  - Fuels management
  - Wildlife habitat
  - Operational efficiency
Could logging utilization data be used to tailor logging residue estimates to the *logging site or stand* level?

- Logging utilization studies have previously focused on the *state* level.
- Enable managers to hone their prescriptions for *site-specific* residue conditions
Research question: Can a site-level model be developed to meet the residue information needs of managers?

- Objectives:
  - **Predict residues** (unutilized growing stock - not tops and limbs) at the *logging site*-level.
  - **Keep it simple** - use variables readily available to land managers.
  - **Reduce costs** - use existing data.
How to meet objectives

- First, parameterize models at the *individual tree level*—gain information on important variables.

- Next, develop *site-level* models that predict residue production.
Methods

- Focus initial efforts on Idaho: data from 815 felled green trees across 33 logging sites during 2008 and 2011 (25 trees per site)
- Tree measurements: outside bark diameter and section lengths ≤ 16 feet
- Identify growing stock residue vs. mill delivered volume (cubic feet)
Methods

- The **response variable** is the ratio “F3”
- F3 is a function of only **bole wood**.
- F3 is **scalable**; beneficial for land managers.

---

**F3, the “growing stock residue factor”**

Growing stock logging residue cubic foot volume (bole wood only) \[=\] Delivered cubic foot volume
Analysis

Individual tree models-

- F3 vs. variables modeled with hierarchical linear mixed models.

- **Model goodness of fit:** rough analog to $R^2 = 0.18$ (n=814 trees)

- Why such a poor fit? Enormous variability from tree to tree.
Analysis

Individual tree models, important variable:

- **Tree diameter** - substantial variability of F3 vs. DBH.

![Graph showing the relationship between DBH and F3](image)

- ![Graph showing predicted F3 vs. DBH](image)
Analysis

Individual tree models, important variable:

- Merchandising - Mechanized vs. by hand (chainsaw).
Analysis

Individual tree models, important variable:

- **Taking pulp** - yes or no.
- Has an *enormous* impact on F3!
- Can substitute smallest top-end diameter of utilized bole instead of taking pulp.
Analysis

Individual tree models, important variable:

Site quality

- Bailey’s Ecoregion Province—strongly related to F3.
## Results

- Individual tree; final model:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Change in F3 (residue/delivered volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MERCHANDISING METHOD</strong>- mechanized vs. chainsaw.</td>
<td>F3 decreases when timber is mechanically processed.</td>
</tr>
<tr>
<td>Mechanical falling also highly correlated to F3.</td>
<td></td>
</tr>
<tr>
<td><strong>DBH</strong>- fit as quadratic term</td>
<td>F3 decreases as DBH increases.</td>
</tr>
<tr>
<td><strong>TAKING PULP</strong>- yes or no</td>
<td>F3 <em>substantially</em> decreases when pulp is taken.</td>
</tr>
<tr>
<td>(includes dbh*pulp interaction)</td>
<td></td>
</tr>
<tr>
<td><strong>ECOREGION</strong>- north or southern Idaho (can substitute habitat type series)</td>
<td>F3 decreases in north Idaho sites.</td>
</tr>
</tbody>
</table>
Results

Can we directly predict residue volume per tree and not the F3 ratio? Yes.

- Residue volume per tree; model has same variables.
Methods

Site-level model

- F3 vs. site-level variables modeled with linear mixed models.

- **Goodness of fit**: = .57 (n=33 sites)
Analysis

Site-level model

- **Quadratic mean dbh** - *NOT* related to F3!
Analysis

Site-level model, important variable:

- **Falling method**- Mechanized vs. by hand (chainsaw).
Analysis

- Site-level model: **important variable**: Taking Pulp - yes or no

- Has an *enormous* impact on F3!

- Can substitute smallest top-end diameter of utilized bole instead of taking pulp.
### Results

**Site-level model**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Change in F3 (residue/delivered volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical harvesting - yes or no</td>
<td>F3 decreases when timber is mechanically felled (e.g. feller buncher).</td>
</tr>
<tr>
<td>Taking pulp - yes or no</td>
<td>F3 <em>substantially</em> decreases when pulp is taken.</td>
</tr>
<tr>
<td>Ecoregion - north or southern Idaho (can substitute habitat type series)</td>
<td>F3 decreases in north Idaho.</td>
</tr>
</tbody>
</table>
Conclusions

- **Individual tree model**: weak relationships, but gained insights about how to construct site-level models.

- **Site level model**: reasonable explanatory value and do not need a tree list to make residue predictions!

- **Models will change** with additional data as logging sites are sampled across Washington, Oregon, Idaho, and Montana.
Applications

- Land manager predictions of site-level residue volumes.
- Use models or data to calibrate predictions of activity fuels and woody debris (example- FVS activity fuels).
- Could adapt models to predict biomass.
- Build on other inventory procedures to create a comprehensive picture of fuels and available biomass feedstocks throughout the Northwest.