Feedstock Supply Curves for Biojet Facilities in the NARA Region

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Brief Outline

- What is NARA
- What I mean by Forest Sector Model
- Why would NARA need such a model
- Example of Logging Residue Supply Curves
  - Integration of Supply Logistics Group NARA research
  - Integration of larger forest products markets
  - Moving across NARA region (OR, WA, ID& MT)
- Future Direction
Northwest Advanced Renewables Alliance

Our Mission:
To provide stakeholders, interested in creating a forest residuals to bio-jet industry, with regional solutions that are economically viable, socially acceptable, and meet the high environmental standards of the Pacific Northwest (WA, OR, ID and MT).

What is NARA?

1000 kg BONE DRY WOODY BIOMASS + DIESEL + HEAT, WATER, & CHEMICALS = ~300 kg LIGNIN AND ~260 LITERS ISOBUTANOL OR ~190 LITERS BIOJET
What is a Forest Sector Model?

- Partial equilibrium model
  - Price endogenous (one to many regions, one to many products)
MARKET BALANCE MUST BE FOUND ACROSS ALL MILLING CENTERS AND LOG SOURCES

LOG BUYERS TRADE-OFF SOURCES TO MINIMIZE COSTS

LOG SELLERS TRADE-OFF DESTINATIONS TO MAXIMIZE NET RETURNS
To evaluate site potential

*Moving back a step*

- it's about log markets
  - Residues are called residues for a reason
  - You need an idea about primary markets
    - The past isn’t always the best predictor of the future
Why project log markets?
What does this market look like?

- FIA data forms the basis for supply
  - It tells us what is out there
  - And perhaps more importantly where

- Manufacturing forms the basis for demand
  - We know what mills are out there and what they make
  - And again, where
What does this market look like?

NARA C2P Region

Log and Biomass Market Model

- Counties
- FIA Plots
- Ownership
  - USFS
  - BLM
  - State
  - Private

NARA Demand Locations

- Logs

0  37.5  75  150 Miles
Biomass Supply Curve

Longview, WA logging residue delivered cost

NARA Model before Supply Logistics

$/bdt

bdt per year

500,000 1,000,000 1,500,000 2,000,000
Boston – What is in the pile

Pile weights were determined using an average weight of 250 pounds per cubic yard of uncompacted Douglas-fir residue. These figures are the result of an earlier phase of this study.

Legend
Green Tons
0 - 26
27 - 91
93 - 301
302 - 402
403 - 1020

Recoverability by Distance
50 ft: 3418 ft - 100%

Landowner: Private
Unit: YellowJacket Cable
Acres: 32
Piles: 16
Species: PISI TSHE PSME
Buncher / hand
Volume: 22 mbf / ac
Residue: 65 GT / ac

Landowner: Stimson
Unit: YellowJacket Shovel
Acres: 29
Piles: 99
Species: PISI TSHE PSME
Felling: Buncher / hand
Skid: Shovel
Volume: 22 mbf / ac
Residue: 60 GT / ac

Yellowjacket Shovel Pile Distance
Recoverability by Distance
50 ft: 504 ft - 29%
100 ft: 1186 ft - 58%
150 ft: 1390 ft - 80%
200 ft: 1462 ft - 84%
250 ft: 1484 ft - 86%
## Boston – What is in the pile

<table>
<thead>
<tr>
<th>Logging System</th>
<th>Study site</th>
<th>Unit Area (Ac)</th>
<th>Residual Volume (Cy/Ac)</th>
<th>Transect Std. (Cy/Ac)</th>
<th>Total Biomass (Cy)</th>
<th>Percent In Piles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed</td>
<td>Fernhopper – WV</td>
<td>40.6</td>
<td>38</td>
<td>4.4</td>
<td>3,254</td>
<td>53.6%</td>
</tr>
<tr>
<td></td>
<td>Numskull - WV</td>
<td>70.2</td>
<td>42</td>
<td>4.8</td>
<td>6,883</td>
<td>59.4%</td>
</tr>
<tr>
<td></td>
<td>High Deck -CAS</td>
<td>9.8</td>
<td>21</td>
<td>17.6</td>
<td>796</td>
<td>75.0%</td>
</tr>
<tr>
<td><strong>System Average</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>67.2%</strong></td>
</tr>
<tr>
<td>Cable</td>
<td>Shot Pouch - CAS</td>
<td>66.7</td>
<td>51</td>
<td>19.7</td>
<td>5,751</td>
<td>42.7%</td>
</tr>
<tr>
<td></td>
<td>Four Way – OC</td>
<td>60.7</td>
<td>45</td>
<td>12.8</td>
<td>4,630</td>
<td>41.9%</td>
</tr>
<tr>
<td></td>
<td>Euchre - OC</td>
<td>33.0</td>
<td>25</td>
<td>2.8</td>
<td>1,772</td>
<td>54.8%</td>
</tr>
<tr>
<td><strong>System Average</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>46.5%</strong></td>
</tr>
</tbody>
</table>
% Area by Harvest System and Distance from Road (NARA region composite)

<table>
<thead>
<tr>
<th>REGION</th>
<th># PLOTS</th>
<th>%AVAIL</th>
<th>G1 -150'</th>
<th>G2- 300'</th>
<th>G3 300+</th>
<th>%C</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR</td>
<td>1973</td>
<td>87.24%</td>
<td>11.14%</td>
<td>11.14%</td>
<td>43.88%</td>
<td>33.83%</td>
</tr>
<tr>
<td>WA</td>
<td>2093</td>
<td>87.61%</td>
<td>12.16%</td>
<td>12.16%</td>
<td>47.76%</td>
<td>27.92%</td>
</tr>
<tr>
<td>ID</td>
<td>675</td>
<td>89.83%</td>
<td>9.02%</td>
<td>9.02%</td>
<td>43.29%</td>
<td>38.67%</td>
</tr>
<tr>
<td>MT</td>
<td>1419</td>
<td>92.27%</td>
<td>2.86%</td>
<td>2.86%</td>
<td>66.29%</td>
<td>28.00%</td>
</tr>
</tbody>
</table>

WHERE

G1 = GROUND-BASED SYSTEMS % LAND AREA 0-150' ROAD OFFSET
G2 = GROUND-BASED SYSTEMS % LAND AREA 150-300' ROAD OFFSET
G3 = GROUND-BASED SYSTEMS % LAND AREA > 300' + OFFSET
C = CABLE-BASED SYSTEMS % LAND AREA
% AVAIL = LAND AREA THAT HAS NOT BEEN RECENTLY HARVESTED

- State and Private FIA Plot Assessment (from Berry 2015)
Marginal cost ($/BDT) to bring forest residues to landing as a function of collection method and distance to landing. Mobilization costs are not considered (from Zamora and Sessions 2015).
What does the harvest look like?

NARA C2P Region

Log and Biomass Market Model

- 2015 Harvest for Pulp
- 2015 Harvest for Export
- 2015 Harvest for Plywood
- 2015 Harvest for Lumber

Counties
### Biomass Model Assumptions

<table>
<thead>
<tr>
<th>Ground At landing</th>
<th>Ground &lt; 150’</th>
<th>Ground 150 – 300’</th>
<th>Ground 300’ +</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Availability</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>from Boston</td>
<td>46.5%</td>
<td>67.2%</td>
<td>67.2%</td>
</tr>
<tr>
<td>from Berry</td>
<td>46.5%</td>
<td>67.2%</td>
<td>67.2%</td>
</tr>
<tr>
<td>Plot specific</td>
<td>25% no swing</td>
<td>25% at landing</td>
<td>75% in field</td>
</tr>
<tr>
<td>from Sessions</td>
<td>25% no swing</td>
<td>75% in field</td>
<td>75% in field</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Costs from Sessions</th>
<th>Collect</th>
<th>Grind</th>
<th>SwingBin</th>
<th>Wait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Older Assumptions for all ground:</td>
<td>20.0</td>
<td>17.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cable In unit</th>
<th>Cable At landing</th>
<th>Ground At landing</th>
<th>Ground At landing</th>
<th>Ground At landing</th>
<th>Ground At landing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>from Sessions</td>
<td>0.00</td>
<td>21.00</td>
<td>21.00</td>
<td>0.00</td>
<td>21.00</td>
</tr>
<tr>
<td>Collect</td>
<td>0.00</td>
<td>21.00</td>
<td>21.00</td>
<td>0.00</td>
<td>21.00</td>
</tr>
<tr>
<td>Grind</td>
<td>21.00</td>
<td>21.00</td>
<td>21.00</td>
<td>21.00</td>
<td>21.00</td>
</tr>
<tr>
<td>SwingBin</td>
<td>21.00</td>
<td>21.00</td>
<td>21.00</td>
<td>21.00</td>
<td>21.00</td>
</tr>
<tr>
<td>Wait</td>
<td>3.50</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Landing**

**Older Assumptions for all ground:**
- **Collect:** 20.0
- **Grind:** 17.5

**NARA**
**Biomass Supply Curve**

I’ll get to this in a bit for you curious types.

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**Longview, WA logging residue delivered cost**

- **NARA Model before Supply Logistics**
- **NARA Model pulp takes none**

![Graph showing long-term cost analysis](image-url)

- Axes: 
  - Y-axis: $/bdt
  - X-axis: bdt per year

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Logistics cost breakdown:

- **NARA Model before Supply**
- **NARA Model pulp takes none**
Disaggregated Biomass Supply Curve

- Millions of BDT per Year
- $/BDT

- Cable System no Rebin
- Cable System Swing Bin
- Ground System at Landing
- Ground System <150' from Landing
- Ground System 150 - 300' from Landing
- Ground System >300' from Landing

NARA
Supply at $65/bdt for Longview

Old    975,521 bdt/yr
New    944,001 bdt/yr

Scale
Bdt/year
- 0 - 250
- 250 - 500
- 500 - 750
- 750 - 1000
- 1000 - 1500
- 1500 - 2000
- 2000 - 2500
- 2500 - 3000
- 3000 - 3500

0 20 40 80 Miles

NARA
What about defect?

• We’ve got great information on where the material is and how much it will cost to collect and transport it, yet the question of how much material there is is still there.
• We assumed 15% defect.
• What if we didn’t?
Where we would get 1 million bdt at $66/bdt if pulp competes for our material it now takes $72/bdt. Assumes that at these prices all tops, breakage, and limbs are left as potential residues. Assumes that at these prices all 25% of tops, 50% of breakage, and 15% of the limbs are taken by pulp mills.

**Biomass Supply Curve**

**Longview, WA logging residue delivered cost**

- NARA Model before Supply Logistics
- NARA Model pulp takes none
- NARA Model pulp takes some

The graph shows the delivered cost per bdt (BDT) per year for different supply scenarios. The x-axis represents the bdt per year, while the y-axis shows the delivered cost per bdt. The graph highlights how changes in supply scenarios impact the delivered cost.
TPO Allometric Studies

TPO data is used to refine the 15% defect assumption?

• University of Montana Bureau of Business and Economic Research: Logging Utilization Research
  – Logging residues are estimated by sampling recently felled trees in active logging sites before trees are yarded to a landing.
  – The ratio of growing-stock residue volume/mill delivered volume can be applied to planned timber harvest volumes to predict residue production at the stand, landscape, or state-level.
    • For example - the residue ratio = 29 cubic feet of growing-stock residue generated per 1,000 cubic feet of mill-delivered volume for the 4-state NARA project area (2008-2013 data).
  – Bole, branch, and foliar biomass (i.e., non-growing stock portions of logging) residues can then be estimated with allometric equations.
Newberg pulp, paper mill to close 'indefinitely;' more than 200 jobs affected

By Alan Drimestone | The Oregonian/OregonLive
on October 16, 2013 at 12:37 PM, updated October 16, 2013 at 2:33 PM

SP Fiber Technologies, a Newberg pulp and paper company, will close "indefinitely" in mid-November and could result in the layoffs of about 200 workers.

WestRock Co., which acquired the mill and other assets earlier this month, has announced that it will "idle indefinitely" the Newberg mill within weeks.

Representatives for WestRock Co., the Richmond, Va., company that announced Oct. 1 it had purchased the Newberg mill along with other assets, delivered the news at the mill Thursday, according to an official in the Newberg city manager's office.

The closure is not necessarily permanent but there's no immediate plan to resume operations, SP Fiber Technologies human resources manager Stacie Gordon informed Newberg City Manager Pro Tem Steve Rhodes. Gordon told Rhodes that the indefinite closure was related to "business conditions," according to an email provided to The Oregonian/OregonLive by the City of Newberg.

WestRock and mill officials said the Newberg mill was one of three WestRock mills to be idled, said Bill Martello, area representative for the Association of Western Pulp and Paper Workers, Local 60, who met with the group.

An idled plant "is held in a ready-to-go state," said Martello, with property and machinery maintained to resume operations.

Of market conditions that affected the decision, Martello said, "The newsprint market is very weak. The dollar has weakened considerably, less exports in the market, demand for newsprint is very weak...

Report: There may be hope yet for Newberg paper mill

By Alan Drimestone | The Oregonian/OregonLive
on October 19, 2013 at 5:39 PM, updated October 19, 2013 at 5:53 PM

A company that is "idling indefinitely" a Newberg paper mill also announced last week that it is closing a mill in Ohio and earlier this month took similar steps with two other mills. An industry newsletter, though, offered hope Monday that the Newberg mill could be spared from a permanent closure.

SP Fiber Technologies of Newberg will close "indefinitely" in mid-November, endangering about 200 jobs. Virginia-based mill owner WestRock Co. told Newberg employees its plan Thursday, two weeks after it announced it had purchased the Yamhill County mill along with other SP Fiber assets.

WestRock is cutting back as the demand for many paper products declines, inventories remain high and export demand declines in part because of the strength of the dollar, industry observers say.

Last week, WestRock confirmed it is closing a paper mill in Coshocton, Ohio, by the end of November, eliminating jobs for 180 hourly workers and 45 salaried employees. And earlier this month, WestRock officials said the paper mill in Uncasville, Connecticut, would be "indefinitely idled" and another mill in Fernandina Beach, Florida, would have one of its paper machines shut down.

In all, six machines at the four mills with capacity to produce 1.15 million tons a year of containerboard and 220,000 tons a year of newsprint are affected, according to the industry publication PPI Pulp & Paper Week.

Meanwhile, an analysis of the shutdowns by KeyBank Capital Markets published Monday said WestRock "is reportedly planning to restart the Newberg mill after some capital investments and changes in grade mix." The analysis cited the
### Regional

**Log Market**
Can do sensitivity analyses for products but have to translate it to log demand

**Individual tree growth**
Can provide sensitivity linkages with detailed sustainability studies in C2P

**Long-run optimal outlook**
5-year periods for longer time frame to get optimal silviculture which drives the long-run log demand

### National

**Product Market**
Can do sensitivity analyses for product demand based on AEO scenarios

**Stand-level growth**
Can provide carbon values, but little other detail for sustainability measures

**Short-run “likely” outlook**
1-year periods for shorter time frame with limited silviculture. Macroeconomic conditions drive demand.
Combined Forest Sector

126 Ports / Border crossings

Land Use and Resource Allocation (LURA) Model

150,350 FIA forestland plots

1,770 Manufacturing facilities
LURA Forest Demand Drivers

U.S. GDP

U.S. Population

U.S. Housing Starts

U.S. Diesel Fuel Price
LURA Forest Demand

Driven by GDP and housing starts

Taken directly from AEO 2015

Driven by GDP
From: USDA NIFA Forest Mortality, Economics and Climate in Western North America (FMEC) Project

- Uses GDP per capita and Internet use to generate elasticities that vary by GDP level
- At current US internet use levels GDP elasticity is negative for Newsprint and Printing and writing papers, but positive for Paperboard and Tissue which were found to be unrelated to internet

LURA Forest Demand

Driven by GDP but shifted due to internet usage. Similar ending point as 2010 RPA, but different path there.
What does the harvest look like?
What does the harvest look like?

Land Use and Resource Allocation (LURA) Model

NARAPlot Harvest
Owner
- BLM
- Ofederal
- Private
- State
- USFS
Refined Biomass Supply Curves

Cheaper residues (more) close to Longview likely due to other demand like Northwest Hardwoods.

More expensive residues (less) in the Longview area possibly due to likely harvest rather than optimal long term harvest.
What does the harvest look like?
Biomass Supply Curves (avg 2015-2035)

Graph showing the supply curves for different locations:
- Longview
- Cosmopolis
- Lewiston
- Spokane
- Missoula

Map showing land use and resource allocation with various land ownership types.
We’ve seen an example of the supply chain linkage here
  – We are evaluating multiple sites across (OR, WA, ID & MT)
  – We need to refine and improve the forest products spatial information (capacities etc)

Also linkages to sustainability
  – Nutrients (Maguire)
  – Soils (Hatten)
  – Habitat (Betts)
Newberg paper mill closure leaves few options for Metro's 127K tons of Portland scrap wood

Metro will need to find a new facility to process hundreds of thousands of tons of reclaimed wood each year.

The local governing body sends the bulk of greater Portland's salvaged timber to a Newberg paper mill to burn as biomass. Now, with news of the facility's pending closure, officials are scrambling to find alternatives.

Metro is working with DEQ and local facilities, as well as its own two solid waste transfer stations, to address the changes caused by the closure, slated for Nov. 15, which will also leave 171 workers jobless. That paper mill processed roughly 88 percent of the reclaimed wood from the greater Portland area, which it burned in its boilers to create steam and electricity and power the mill. Last year, it received about 127,000 tons of wood.