Residue Trucking Model

[Image of a computer screen showing a forest residue trucking model interface.]

1. Define the route (miles of each road type and/or speeds)
2. Describe materials
3. Select Equipment (see "Costs" page to review assumptions)
4. Verify Productivity Assumptions (adjust any necessary values)
Outline

- Overview of FoRTS
- Review of analysis concepts
- Example scenario
Model objectives

- Estimate transportation costs for biomass
- Evaluate alternative routing
- Understand the impact of system balance
- Determine economic feasibility of 2-stage transport options
1. Route Description

- Unimproved forest
  - 1st Stage Transport: 2.5 miles
  - 2nd Stage Transport: 10 miles
- Gravel, improved
  - 1st Stage Transport: 15 miles
  - 2nd Stage Transport: 15 miles
- 2-lane paved
  - 1st Stage Transport: 30 miles
  - 2nd Stage Transport: 40 miles
- State highway
  - 1st Stage Transport: 50 miles
  - 2nd Stage Transport: 50 miles
- Interstate
  - 1st Stage Transport: 60 miles
  - 2nd Stage Transport: 60 miles

2. Materials

- Residue Species
  - Grand fir, pine
  - Industrial legs/pole
  - Douglas fir
  - Western larch

- Moisture content
  - 40% (d.b.)
  - 30% (d.b.)

- Solid Vol. Factor
  - 0.2
  - 0.4

- Load Density
  - 204 lbs/cy
  - 379 lbs/cy

3. Equipment

- In-woods loading
  - Knuckleboom loader
  - Skidder

- 1st Stage Transport
  - RO container
  - Dump truck

- Processing
  - Chipper
  - RO chipping

- 2nd Stage Transport
  - Dump truck
  - Chipper van

4. Productivity

- In-woods loading
  - Loading rate: 60 tons/PMH
  - Base utilization: 0.8 PMH/SMH

- 1st stage haul
  - Standing time: 10 min/trip (includes hooking, drop, other tasks)
  - Round Trip Minutes: 30 min/trip on the road
  - Payload: 4 (bdw)

- Processing
  - Production rate: 40 tons/PMH
  - Base utilization: 0.8 PMH/SMH
5. System balance and cost

Production Comments
- In-woods loading is limiting
- 2nd stage haul is limiting
- Processing and 2nd stage haul exceed capacity of 1st stage

### 4. System Production and Cost Calculation

| # of each | (tons/SMH) | Act. Util. | $/ton  | $/bd
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading</td>
<td>1</td>
<td>20</td>
<td>0.68</td>
<td>$5.73</td>
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<tr>
<td>1st Stage</td>
<td>2</td>
<td>19</td>
<td>0.90</td>
<td>$5.59</td>
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<tr>
<td>Processing</td>
<td>1</td>
<td>48</td>
<td>0.55</td>
<td>$5.33</td>
</tr>
<tr>
<td>2nd Stage</td>
<td>3</td>
<td>33</td>
<td>0.90</td>
<td>$5.52</td>
</tr>
</tbody>
</table>

**Total Cost:** $22.17 $26.60

To comment on this tool, please contact:
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- How to Use the Model
- Definitions
- Production
- Intermediate Values
- Equipment
- Costs
Forest Residues Transportation Costing Model

Introduction
The Forest Residues Transportation Model is a spreadsheet calculator designed to help you compare alternative methods of moving biomass from the forest to a wood-using facility. It will let you:
1. estimate loading and hauling costs for different combinations of equipment
2. evaluate the best mix (numbers and types) of equipment
3. compare different hauling routes
4. examine reloading, or two-stage hauling opportunities
You can use default values for basic comparisons or input your own numbers to examine specific projects.

The model will NOT give actual costs for these operations because it does not include factors such as profit and overhead. It is intended to represent a relative comparison among options.

Basic Operation
• The model has 6 separate pages: "Production", "Costs", "Definitions", "How to Use", "Equipment" and "Intermediate Values". Click on the labeled tabs at the bottom of the page to move from one section to another.
• The Production page is the final report that will summarize all the inputs and results.
• You can type over anything that is in white boxes to enter your own information.
• If you click on any "radio buttons" (the empty dots) for selections, the program will enter numbers automatically for you. (This may replace numbers you have already entered)
• To print a copy of your analysis, select "File", "Print" and either "Active Sheet" or "Entire Workbook"
• To save a unique copy of your analysis, select "File", "Save as", and enter a new name.

Running a Scenario
1. Start on the Production page and type in a Project name and a description of your scenario.
2. Describe the transportation route (distance) for 1st Stage hauling and 2nd Stage hauling. 1st Stage: 2nd Stage:

How to Use the Model
Definitions of terms used in the model

1st stage transport—hauling biomass from the woods to a reload or processing point
2nd stage transport—hauling material to the final delivery point
actual utilization—the adjusted utilization that a machine may achieve working as part of a system of inter-related equipment
base utilization—the maximum ratio of productive time to scheduled time that a machine may be capable of attaining working by itself. This does not reflect under-use due to system limiting factors such as the capacity of other equipment.
basic labor rate—the wage rate for labor or take-home pay rate
benefits—additional labor charges including worker’s compensation insurance, medical, FICA, sick leave or vacation, etc. Entered as a percent of wages. Minimum is at least 30% and is highly variable depending on region, ownership structure, safety experience.
bone dry ton (bd) — quantity of wood that weighs 2000 lbs at oven-dry moisture content
bone dry unit (bdu) — quantity of wood that weighs 2400 lbs at oven-dry moisture content
fixed costs—those costs that must be paid whether an asset is working or not. Generally expressed as $/scheduled machine hour.
insurance—coverage for property loss and/or liability. Varies by type of equipment, region, limits, and owner experience. This value is entered as the annual premium payment ($/yr)
interest rate—value assumed to reflect the time value of money to the user. This could be the interest rate on borrowed funds or it could be the alternative rate of return of capital funds.
life—the period of time over which an asset is depreciated (yr). A general rule of thumb for logging machines is 5 years. For comparisons, this should be the same for similar machines.
misc. operating costs—charge for any other consumables such as fuel, chains, saw blade, teeth, entered as $ per operating hour.
mist content (MC)—weight of water in wood — weight of oven-dry wood, expressed as a percent. For example, 50% MC means the amount of water in the wood weighs half as much as the dry wood itself.
productive machine hour (PMH)—a complete hour in which the machine only performs productive work
repair and maintenance (R&M)—cost to keep equipment operational. The R&M costs change over the life of the machine, increasing as a machine gets older. Machine rates use an average decimal percentage of depreciation as an estimator. Entering 0.9, for example, means that R&M will cost 90% of the annual depreciation charge. Over the life of the MLs, how to use the model, definitions, intermediate values, equipment, costs
### Default Values

These numbers are loaded into the cost page when equipment is selected.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Purchase Price</td>
<td>$181,030</td>
<td>$355,500</td>
<td>$50,000</td>
<td>$200,000</td>
<td>$350,000</td>
<td>$580,000</td>
<td>$610,000</td>
<td>$138,000</td>
<td>$300,000</td>
<td>$125,000</td>
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<tr>
<td>Life yrs</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Salvage (% of new)</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Interest rate</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
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<tr>
<td>Insurance ($/yr)</td>
<td>$3,600</td>
<td>$7,000</td>
<td>$1,000</td>
<td>$4,000</td>
<td>$9,000</td>
<td>$12,000</td>
<td>$12,000</td>
<td>$6,000</td>
<td>$6,000</td>
<td>$6,000</td>
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<td>Taxes/tags</td>
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<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
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<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
</tbody>
</table>

### Total Tire Cost ($/yr)

- **[4]** 2,000
- **[6]** 6,000
- **[8]** 2,500
- **[10]** 20,000
- **[12]** 3,500

- **Tire life (yrs)**: 4
- **Fuel cost ($/q)**: $1.80
- **Oil cost ($/q)**: $2.00
- **Horsepower**: 174
- **Fuel Cons (g/hp.hr)**: 0.022
- **Oil use (% of fuel)**: 0.37
- **R&M (% of dep.)**: 0.90
- **Misc. oper. ($/PMH)**: $15.75
- **Base Utilization**: 0.8
- **Bone-dry tons/PMH**: 60

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**Intermediate Calculations From Costs Page**

- Do NOT change these values

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**Default Data References**

1. [Time and Material](#) for equipment, [labor](#), and [tools](#) is provided by the user. [Model](#) is used for equipment and costs in trays, cost, and [intermediate](#) values.

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<table>
<thead>
<tr>
<th>In-woods load</th>
<th>1st Trans</th>
<th>Process</th>
<th>2nd Trans</th>
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</thead>
<tbody>
<tr>
<td>Depreciation/yr</td>
<td>$66,890.00</td>
<td>$22,080.00</td>
<td>$97,800.00</td>
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<tr>
<td>Capital Rec Factor</td>
<td>0.2630</td>
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<td>Salvage Value</td>
<td>$71,100.00</td>
<td>$27,800.00</td>
<td>$122,000.00</td>
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<td>Fuel Cons (g/PMH)</td>
<td>8.85</td>
<td>1.50</td>
<td>30.00</td>
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</table>
## Machine Costs

### FIXED COST INPUTS

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<thead>
<tr>
<th></th>
<th>Wheel</th>
<th>Container</th>
<th>1st transport</th>
<th>Horizontal</th>
<th>2nd transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase price</td>
<td>$205,000</td>
<td>$138,000</td>
<td>$580,000</td>
<td>$146,000</td>
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<tr>
<td>Machine life (yrs)</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td></td>
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<tr>
<td>Salvage value (% of new)</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
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<tr>
<td>Interest rate (%)</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td></td>
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<tr>
<td>Insurance (Ann Prem.)</td>
<td>$4,000</td>
<td>$6,000</td>
<td>$12,000</td>
<td>$6,000</td>
<td></td>
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<tr>
<td>Taxes/fees (% of new)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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</tbody>
</table>

### OPERATING COST INPUTS

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<th>2nd transport</th>
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<tr>
<td>Tire cost (total)</td>
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<td>$2,500</td>
<td>$2,500</td>
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<td></td>
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<tr>
<td>Tire life (years)</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local fuel cost ($/gal)</td>
<td>$1.80</td>
<td>$1.80</td>
<td>$1.80</td>
<td>$1.80</td>
<td></td>
</tr>
<tr>
<td>Local oil cost ($/gal)</td>
<td>$2.00</td>
<td>$2.00</td>
<td>$2.00</td>
<td>$2.00</td>
<td></td>
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<tr>
<td>Horsepower</td>
<td>190</td>
<td>430</td>
<td>860</td>
<td>430</td>
<td></td>
</tr>
<tr>
<td>Fuel Consumption (g/hp/hr)</td>
<td>0.021</td>
<td>5</td>
<td>0.028</td>
<td>5</td>
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</tr>
<tr>
<td>Oil and lubrication (%)</td>
<td>0.10</td>
<td>0.1</td>
<td>0.13</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Repair &amp; Maint (%)</td>
<td>0.6</td>
<td>0.6</td>
<td>0.75</td>
<td>0.6</td>
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<tr>
<td>Misc. consumables (%)</td>
<td>0.28</td>
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</tbody>
</table>

### LABOR COST INPUTS

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<th>2nd transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic labor rate</td>
<td>$10</td>
<td>$10</td>
<td>$10</td>
<td>$10</td>
<td></td>
</tr>
<tr>
<td>Benefits (% of base)</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
<td></td>
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<tr>
<td>Fixed cost ($/SMH)</td>
<td>$25.63</td>
<td>$14.73</td>
<td>$73.00</td>
<td>$15.41</td>
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<tr>
<td>Variable costs ($/PMH)</td>
<td>$25.32</td>
<td>$8.29</td>
<td>$102.38</td>
<td>$18.60</td>
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<tr>
<td>Labor costs ($/SMH)</td>
<td>$23.94</td>
<td>$23.94</td>
<td>$23.94</td>
<td>$23.94</td>
<td></td>
</tr>
</tbody>
</table>
Production and Utilization

- Productive Machine Hours vs. Scheduled Machine Hours

Utilization = PMH/SMH

\[ .75 = 6 \text{ PMH}/8 \text{ SMH} \]
Single axle

20,000 lb 10,000 lb

18,400 lb

20,000 lb 10,000 lb
Tandem axle

- 11,000 lb
- 26,000 lb
- 34,000 lb
Tri-axle

11,000 lb

30,000 lb

42,000 lb
Tractor-trailer

- 34,000 lb
- 12,000 lb
- 51,000 lb
- 34,000 lb
- 34,000 lb
Chip van

12,000 lb  34,000 lb  51,000 lb
Container Double

31,000 lb  31,000 lb  31,000 lb  12,000 lb
Container payloads

- 50 yd bin—tare 8,500#
- Pup trailer—tare 10,000#
- Tractor with hooklift—tare 28,200#

- Legal payload as a single—10,000#
- Legal payload as a double—46,000#
Cubed or Grossed?

- User defines moisture content and SVF, the model calculates green wt/cubic yd
- User defines transport volume capacity and legal payload
- The model checks:
  - If $\text{volume} \times \text{density} > \text{legal load}$ (grossed out)
  - If $\text{volume} \times \text{density} < \text{legal load}$ (cubed out)
Machine Costing

- Machine Rate—average unit costs over the ownership life of the asset
- Fixed costs accrue on SMH; Variable costs accrue on PMH
- Capital recovery
- Big assumptions: Repair & maint
- Doesn’t include all costs (P&O)
Costs

- Ownership costs: (5 yr, 20% salv)
  - Annual depreciation, IIT

![Graph showing the relationship between purchase price and cost per million hours (PMH) for two different hours per year: 1000 hr/yr and 1500 hr/yr. The graph illustrates a linear increase in cost with purchase price, with the red line representing 1000 hr/yr and the yellow line representing 1500 hr/yr.]
Effect of machine life

![Graph showing the effect of machine life on purchase price: 3 yr, 5 yr, and 7 yr lines represent different trends in purchase price as the machine life increases.](image-url)
Fuel and Lube

- Fuel consumption for logging machines is based on gal/hp-hr

\[
\frac{14 \text{ gal/hr}}{500 \text{ hp}} = 0.028 \text{ gal/hp-hr}
\]

- Fuel consumption for trucks is in miles/gal
Petroleum products pricing

On-Highway Diesel Fuel Prices

Cents per Gallon

May Aug Nov Feb May

2003-04 2004-05
System Balancing

The production of connected pieces is limited by the slowest operation in the system.

Loader: 40 tons/PMH
Grinder: 80 tons/PMH

Loader: 36 tons/SMH (90% ut)
Grinder: 36 tons/PMH (50% ut)