# SHORTFOR WP3: Economical sustainability of SRF

Markets and Values

Stand Volume / Biomass

Supply Chain Costs

# Characterisation of SRF supply chains

# SRF Supply Chains

| Harvest Method | Products | Machine system | Haulage |
|---|---|---|---|
| | | | |
| Cut to length | Roundwood | Harvester, Forwarder | Timber trucks |
| | | | |
| Integrated (loose residues) | Roundwood, Wood fuel | Harvester, Forwarder, Chipper | Timber trucks, Walking Floors |
| | | | |
| Intergrated (bundled residues) | Roundwood, Wood fuel | Harvester, Forwarder x 2, Shredder | Timber trucks |
| | | | |
| Whole tree | Wood fuel | Feller buncher, terrain chipper, chips forwarder | Chip Vans / walking floors |

# Machine Productivity models

| Machine | Country | Operation | Method | Species | Productivity | Covariate | Covariate Range | Model | Parameters | Machine specifications | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Harvester** | Ireland | Clearfell | CTL | not stated | 13.5 $m^3$ – 60.5 $m^3$ / PMH | Tree size | 0.1 $m^3$ – 1.0 $m^3$ | $Y = 60.711x^{0.6545}$, $R^2$ = 0.9219 | Y = productivity ($m^3$ / PMH), x – average tree size ($m^3$) | Global model for numerous machines | Jiroušek et al. (2007) |
| **Feller Buncher (shears)** | Italy | Clearfell | WT | Poplar SRF | 173 trees / PMH, 18.6 ODT / PMH, 45.1 $m^3$ / PMH | n/a | Mean dbh of 20 cm | Average | n/a | Biasi Shear head on Hitachi EX 165 | Schweier et al. (2015) |
| **Feller Buncher (chainsaw)** | Ireland | Clearfell | WT | Birch | 5.24 $m^3$ solid / PMH | n/a | Mean dbh of 9 cm | Average | | Silvatec 656TH feller-buncher | Kent & Kofman (2007) |
| **Forwarder** | Ireland | Clearfell | CTL | not stated | 10 $m^3$ – 35 $m^3$ / PMH | Distance, machine size | Distance 80 m – 1400 m. Three machine size classes; Class 1: <80 kW, payload<10 tonnes Class 2: 80 kW to 120 kW, payload 10 – 12 tonnes Class 3: >120 kW, payload > 12 tonnes | $Class\ 1, Y = 10.5193x^{(24.9181/x)}$, $R^2$ = 0.5221 $Class\ 2, Y = 17.0068x^{(13.2533/x)}$, $R^2$ = 0.6263 $Class\ 3, Y = 10.5193x^{(24.9181/x)} + 10$, $R^2$ not stated | Y = productivity ($m^3$/PMH), x = average hauling distance (m) | Global model for numerous machines | Jiroušek et al. (2007) |
| **Tractor mounted terrain chipper** | Ireland | Clearfell | WT | Birch | 5.5 $m^3$ solid volume / PMH | n/a | Mean dbh of 9 cm | Average | n/a | TP280 tractor-mounted terrain chipper on a Valtra tractor and trailer | Kent & Kofman (2007) |
| **Residue Bundler** | Spain | Clearfell | CTL | Eucalyptus (E. globulus) | 4.94 ODT / PMH | n/a | n/a | Average | n/a | Woodpac ENFO 2000 | Garcia et al. (2011) |
| **Feller buncher (circular saw)** | USA, Pacific Northwest | Clearfell | WT | Poplar SRF | 430 trees / PMH, 21.96 ODT / PMH | n/a | Mean dbh 17 | Average | n/a | Quadco 56-cm hotsaw mouted on an excavator Timbco TE820 | Spinelli and Hartsough (2006) |
| **DDC Chipper (Delimb, Debark, Chip)** | USA Pacific Northwest | Clearfell | WT | Hybrid poplar | 26.1 ODT of clean chip / PMH | n/a | Mean dbh 16.5 cm | Average | n/a | Peterson Pacific DDC 5000 | Hartsough et al. (2002) |
| **DDC Chipper (Delimb, Debark, Chip)** | Australia, sunshine coast | Clearfell | WT | Eucalyptus globulus | 25.61 ODT / PMH | n/a | Mean dbh of 17.8 | Average | n/a | Peterson Pacific DDC 5000 | Ghaffariyan and M. Brown (2013) |
| **Chipper** | Ireland | Roadside during thinning | WT | Ash | 22.5 $m^3$ solid vol. / PMH | n/a | Mean dbh 8 cm | Average | n/a | Jenz Hem700 mounted on a truck | Kent and Kofman 2007 |
| **Chipper (roadside and terrain, global model)** | Italy | Various | Various: whole tree, tops, residues | Various | see models | Engine size, piece size | 22 – 440 kW, 0.001 – 1.000 green tonnes | $Chip\ (\mathrm{min}tonne^{-1}) = 0.02 + \frac{13.1}{Piece\ Size \times Power} + 566/(Power)$ $R^2$ = 0.79 $Reposition\ (\mathrm{min}tonne^{-1}) = 0.584 + 0.00744(\frac{In\ Stand\ Dummy}{Piece\ Size}) - 0.385(Self\ Prop.Dummy)$ $R^2$= 0.48 $Other\ (\mathrm{min}tonne^{-1}) = 0.2 + \frac{0.0157}{Piece\ Sieze} + 4.72(Small\ Chipper\ Forwarder\ Dummy)$ $R^2$=0.73 | Piece size = as received weight per piece (tonnes) Power = chipper engine size / PTO power In Stand Dummy = 1 if in stand chipping, 0 if at the roadside Self Prop. Dummy = 1 if chipper is self propelled, 0 otherwise Small chipper Forwarder Dummy = 1 if chipper is a small chipper-forwarder, 0 | Global model for numerous machines | Spinelli and Hartsough (2001) |

# Machine Rate

| Harvester 1070D | | | |
|---|---|---|---|
| Initial Investment | Euro | 365000 | John Deere |
| Machine Power | kw | 136 | |
| Salvage Value | Euro | | |
| Economic Life | years | | |
| Scheduled Operating hours | hrs/year | | |
| Utilisation Percentage | % | | |
| Productive Machine Hours | hrs/year | | |
| | | | |
| Interest Rate | % | | |
| Insurance and tax rate | % | | |
| Repair an Maintenance | % of depreciation | | |
| Depreciation | Euro/year | | |
| Average Yearly Investment | Euro/year | | |
| Interest | Euro/year | | |
| Insurance and Tax | Euro/year | | |
| | | | |
| | | | |
| | | | |
| Maintenance and Repair | Euro/pmh | | |
| Fuel Consumption Rate | Litres / pmh | | |
| Cost of litre of fuel (ex vat) | | | |
| Fuel | Euro/pmh | | |
| Lubrication Consumption Rate | | | |
| Lubrication | Euro/pmh | | |
| | | | |
| Labour, wages per hour | Euro / SMH | | |
| Benefits Rate | | | |
| Annual cost | Euro per annum | | |
| | | | |
| Labour Cost per PMH | Euro/pmh | | |
| Overheads % | % | | |
| Operating Profit % | % | | |
| | | | |
| Ownership cost per SMH | Euro/smh | | |
| Ownership cost per PMH | Euro/pmh | | |
| | | | |
| Operating cost per PMH | Euro/pmh | | |
| Operating cost per SMH | Euro/smh | | |
| | | | |
| | | | |
| Overheads per SMH | Euro/smh | | |
| Operating Profit Per SMH | Euro/smh | | |
| | | | |
| Total Rate per SMH | Euro/smh | | |
| Total Rate per PMH | Euro/pmh | | |

| Forwarder 810D E | | | |
|---|---|---|---|
| Initial Investment | Euro | 235000 | John Deere |
| Machine Power | kw | 86 | |
| Salvage Value | Euro | 47000 | 20% |
| Economic Life | years | 6.9 | Coillte |
| Scheduled Operating hours | hrs/year | | |
| Utilisation Percentage | % | | |
| Productive Machine Hours | hrs/year | | |
| | | | |
| Interest Rate | % | | |
| Insurance and tax rate | % | | |
| Repair an Maintenance | % of depreci | | |
| Depreciation | Euro/year | | |
| Average Yearly Investment | Euro/year | | |
| Interest | Euro/year | | |
| Insurance and Tax | Euro/year | | |
| | | | |
| | | | |
| | | | |
| Maintenance and Repair | Euro/pmh | | |
| Fuel Consumption Rate | Litres / pmh | | |
| Cost of litre of fuel (ex vat) | | | |
| Fuel | Euro/pmh | | |
| Lubrication Consumption Rate | | | |
| Lubrication | Euro/pmh | | |
| | | | |
| Labour, wages per hour | Euro / SMH | | |
| Benefits Rate | | | |
| Annual cost | Euro per ann | | |
| | | | |
| Labour cost per PMH | Euro/pmh | | |
| Overheads % | % | | |
| Operating Profit % | % | | |
| | | | |
| Ownership cost per SMH | Euro/smh | | |
| Ownership cost per PMH | Euro/pmh | | |
| | | | |
| Operating cost per PMH | Euro/pmh | | |
| Operating cost per SMH | Euro/smh | | |
| | | | |
| | | | |
| Overheads per SMH | Euro/smh | | |
| Operating Profit Per SMH | Euro/smh | | |
| | | | |
| Total Rate per SMH | Euro/smh | | |
| Total Rate per PMH | Euro/pmh | | |

| Machine | Unit | Brash Bundler | Forwarder 1110E | Harvester | Forwarder 810E | Shredder | Excavator (loader) |
|---|---|---|---|---|---|---|---|
| **Fixed Costs** | | | | | | | |
| Purchase Price (€) | € | 425,000 [a] | 265,000 [a] | 332,000 | 200,000 | 330,000 [b] | 100,000 [c] |
| Salvage Value (€) | € | 55,250 | 34,450 | 43,160 | 26,000 | 42,900 | 13,000 |
| Economic Life (PMH) | PMH | 18,000 [f] | 18,000 [f] | 18,000 | 18,000 [f] | 7,000 [e] | 18,000 [f] |
| Annual Depreciation (€) | €/year | 36,153 [i] | 22,543 [i] | 27,681 | 17,013 [i] | 72,185 [i] | 8,507 [i] |
| Insurance cost (€) | €/year | 7,746 [i] | 4,830 [i] | 6061 | 3,645 [i] | 6,676 [i] | 1,823 [i] |
| Machine power kW | kW | 134 | 135 | 129 | 95 | 375 | 65 |
| **Total Fixed Costs** | **€** | **41.11** | **25.21** | **31.24** | **20.08** | **56.57** | **9.06** |
| **Variable Costs** | | | | | | | |
| Fuel Cost (€/l) | €/litre | 0.88 [e] | 0.88 [e] | 0.88 | 0.88 [e] | 0.88 [e] | 0.88 [e] |
| Average Fuel Consumption (l/PMH) | litre | 10.4 [h] | 10.4 [h] | 10.0 | 7.4 [h] | 58.13 [h] (50%) | 5.1 [h] |
| Fuel cost per hour (€) | € | 9.13 | 9.18 | 8.80 | 6.48 | 51.15 | 4.46 |
| Lubrication cost (% of fuel costs per PMH) | % | 15% [h] | 15% [h] | 15% | 15% [h] | 15% [h] | 15% [h] |
| Maintenance and Repair (% of replacement value) | % | 100% [h] | 80% [h] | 100% | 80% [h] | 100% [h] | 80% [h] |
| Number of additional track sets | | 1 | 2 | 2 | 2 | - | - |
| Cost per track set (€) | € | 5500 [e] | 5500 [e] | 5,500 | 5500 [e] | - | - |
| Estimated track set life (PMH) | PMH | 18000 [e] | 6000 [e] | 18,000 | 6000 [e] | - | - |
| Consumables | € / PMH | 21 [a] (Saw bar, saw chain, bundler twine) | - | 1.30 / PMH (saw bar and chain) (Karha et al 2004) | - | 24.06 [b] (Hammers, Knives) | - |
| | | | - | | - | | - |
| **Total Variable Costs** | **€** | **55.41** | **23.94** | **31.94** | **21.28** | **131.03** | **9.58** |
| **Operator Costs** | | | | | | | |
| Number of Shifts | | 1 | 1 | 1 | 1 | 1 | 1 |
| Cost/ Hour (incl. Benefits) (€) | € | 15 [e] | 15 [e] | 15 [e] | 15 [e] | 15 [e] | 15 [e] |
| Operator Insurance (€/a) | € | 1,200 [e] | 1,200 [e] | 1,200 [e] | 1,200 [e] | 1,200 [e] | 1,200 [e] |
| **Total Operator Direct Costs** | **€** | **23.82** | **23.82** | **22.43** | **23.82** | **20.64** | **20.64** |
| **Productivity and Operations** | | | | | | | |
| Work Days per year | | 250 | 250 | 250 | 250 | 250 | 250 |
| Shifts per day | | 1 | 1 | 1 | 1 | 1 | 1 |
| Hours per shift | | 10 | 10 | 10 | 10 | 10 | 10 |
| Machine Utilisation (%) | % | 65 [g] | 65 [g] | 69 [g] | 65 [g] | 75 [g] | 75 [g] |
| Overhead Costs (%) | % | 5 [h] | 5 [h] | 5 [h] | 5 [h] | 5 [h] | 5 [h] |
| Normal operating profit (%) | | 5 [h] | 5 [h] | 5 [h] | 5 [h] | 5 [h] | 5 [h] |
| **Net Cost PMH** | **€** | **120.34** | **72.97** | **85.61** | **65.17** | **208.24** | **39.28** |
| **Gross Costs PMH** | **€** | **131.42** | **79.20** | **93.81** | **70.60** | **228.50** | **42.22** |

Irish FITPAC Model

August 2008
Version 1.10

Glen Murphy

# IRISH TRUCK PRODUCTIVITY AND COSTING MODEL

Route Number

Date

Outputs

Clear | Print

**Truck Configuration**

Articulated | Rigid + Trailer

With Crane

Axles: 3 - 4 | 5 | 6

SELECT LOAD TYPE FIRST

Current Fuel Costs (€/litre): 0.00

**Load Type (Select this First)**

Logs Only | Logs + Other

Slash: Loose | Slash: Bundle

Chips: Clean | Boiler fuel

**Extras to be Included**

- [x] Labour
- [x] Overheads
- [ ] Pickup
- [ ] Separate Loader

Calculate Costs

**Work Sheets**

Labour
Overheads
Pickup
Separate Loader
Truck and Trailer
Routes
Speeds and Loads
Conversion Factors
Instructions
Raw Data

**Annual Costs (€ per annum)**

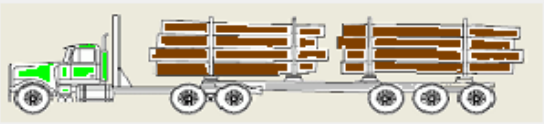
| | | |
|---|---|---|
| Labour | | 0 |
| Overheads | | 0 |
| Pickup | | 0 |
| Separate Loader | | 0 |
| Truck and Trailer | | 0 |
| Other Equipment Costs (if any) | 0 | |
| Sub-total | | 0 |
| Profit | 0 (% of Costs) | 0 |
| **Total Costs (€ per annum)** | | **0** |

**Trucking Rate**

| | |
|---|---|
| Prod'n estimate (tonne-km per annum) | 0 |
| Trucking rate (€/tonne-km) | 0.000 |
| Trucking rate (€/tonne-km rounded) | 0.00 |
| Trip Cost (€/tonne) for 0 km (one-way) is: | **0.00** |

**Energy Profile**

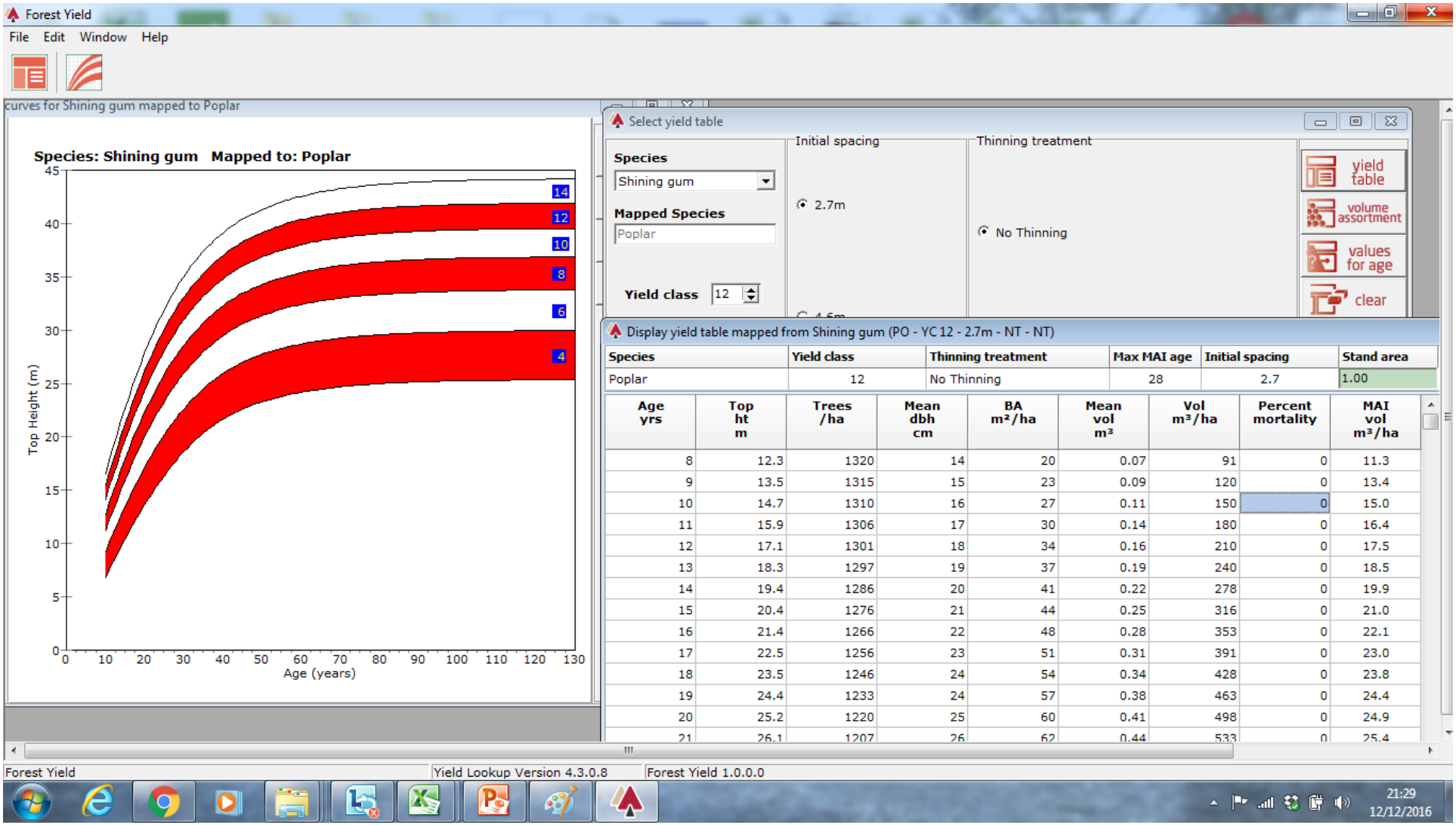
| | |
|---|---|
| Fuel Consumption for Route: Per Day (litres) | 0 |
| Fuel Consumption for Route: Per Year (litres) | 0 |
| Fuel Consumption for Trip: (litres) | 0 |



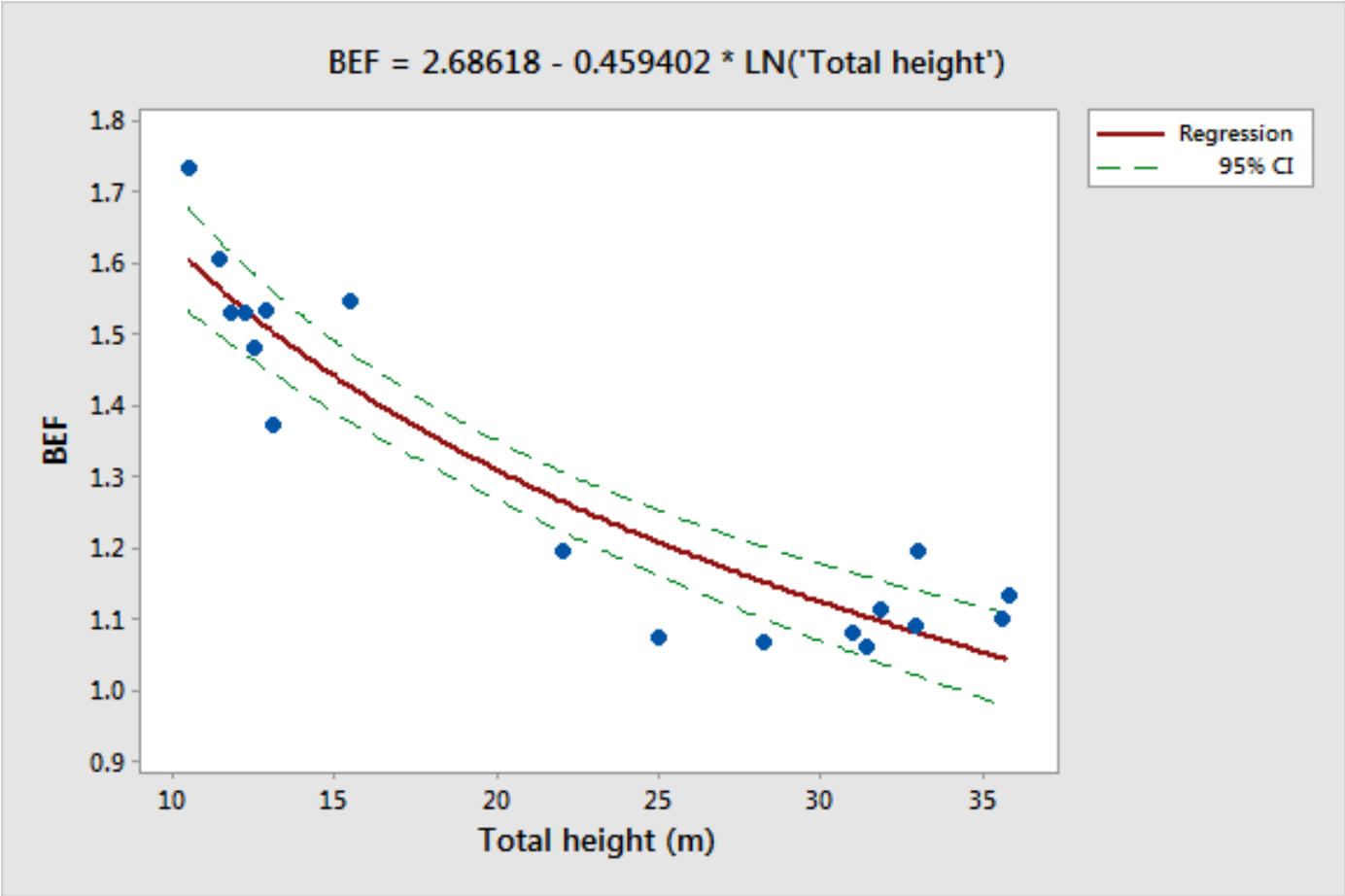
Acknowledgement: Parts of this model are based on the Truck Costing Model originally developed by the New Zealand Logging Industry Research Organisation in the mid-1990's.

Exit

# Yield Model


Forest Yield
File Edit Window Help
curves for Shining gum mapped to Poplar
Species: Shining gum Mapped to: Poplar
Top Height (m)
Age (years)
14
12
10
8
6
4
Select yield table
Species
Shining gum
Mapped Species
Poplar
Yield class 12
Initial spacing
2.7m
Thinning treatment
No Thinning
yield table
volume assortment
values for age
clear
Display yield table mapped from Shining gum (PO - YC 12 - 2.7m - NT - NT)
Species | Yield class | Thinning treatment | Max MAI age | Initial spacing | Stand area
Poplar | 12 | No Thinning | 28 | 2.7 | 1.00
Age yrs | Top ht m | Trees /ha | Mean dbh cm | BA m²/ha | Mean vol m³ | Vol m³/ha | Percent mortality | MAI vol m³/ha
8 | 12.3 | 1320 | 14 | 20 | 0.07 | 91 | 0 | 11.3
9 | 13.5 | 1315 | 15 | 23 | 0.09 | 120 | 0 | 13.4
10 | 14.7 | 1310 | 16 | 27 | 0.11 | 150 | 0 | 15.0
11 | 15.9 | 1306 | 17 | 30 | 0.14 | 180 | 0 | 16.4
12 | 17.1 | 1301 | 18 | 34 | 0.16 | 210 | 0 | 17.5
13 | 18.3 | 1297 | 19 | 37 | 0.19 | 240 | 0 | 18.5
14 | 19.4 | 1286 | 20 | 41 | 0.22 | 278 | 0 | 19.9
15 | 20.4 | 1276 | 21 | 44 | 0.25 | 316 | 0 | 21.0
16 | 21.4 | 1266 | 22 | 48 | 0.28 | 353 | 0 | 22.1
17 | 22.5 | 1256 | 23 | 51 | 0.31 | 391 | 0 | 23.0
18 | 23.5 | 1246 | 24 | 54 | 0.34 | 428 | 0 | 23.8
19 | 24.4 | 1233 | 24 | 57 | 0.38 | 463 | 0 | 24.4
20 | 25.2 | 1220 | 25 | 60 | 0.41 | 498 | 0 | 24.9
21 | 26.1 | 1207 | 26 | 62 | 0.44 | 533 | 0 | 25.4
Forest Yield
Yield Lookup Version 4.3.0.8
Forest Yield 1.0.0.0
21:29
12/12/2016

Biomass expansion factor




For now, using top height as an input

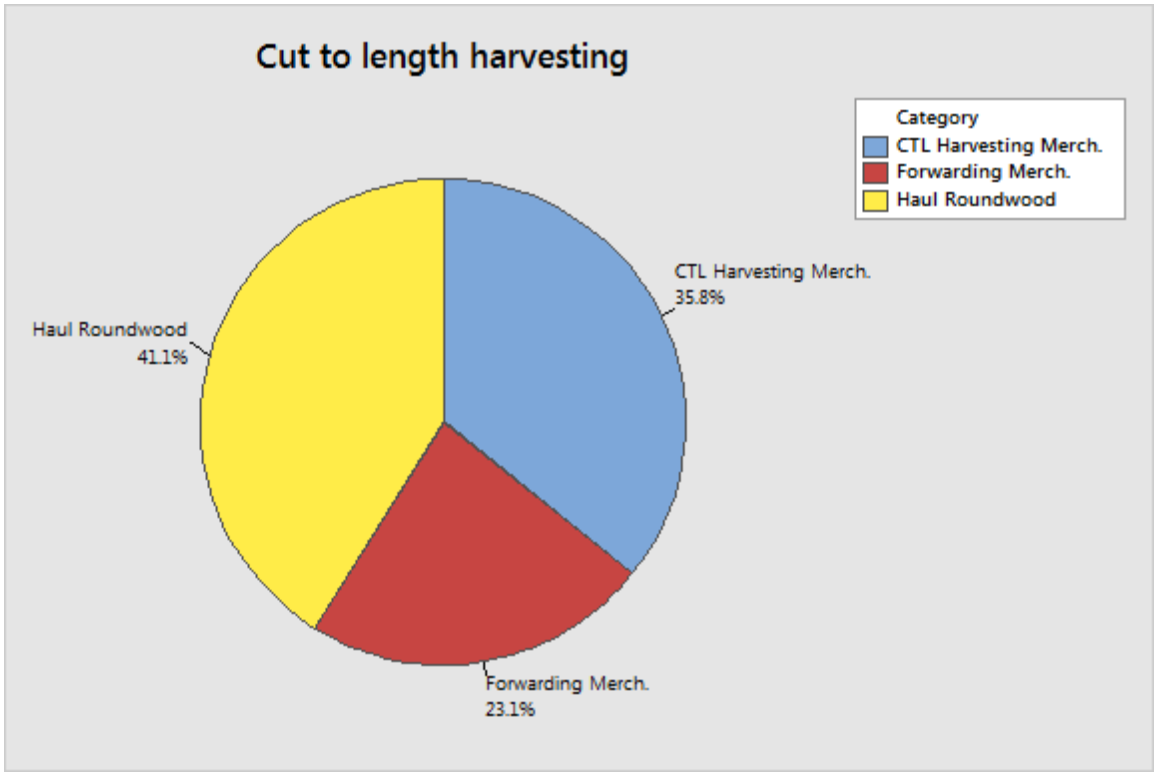
# Results: In progress

Scenario:
YC: 10
Harvest year: 15
Extraction Distance: 200 m
Haulage Distance: 50 km

**CTL harvesting**

| Merch. |
|---|
| Merch. Volume / ha |
| 258 |

| Operation | | Cost / ha € |
|---|---|---|
| CTL Harvesting Merch. | Y | 1744 |
| Forwarding Merch. | Y | 1129 |
| Haul Roundwood | Y | 2005 |




Fuel Characteristics: Database

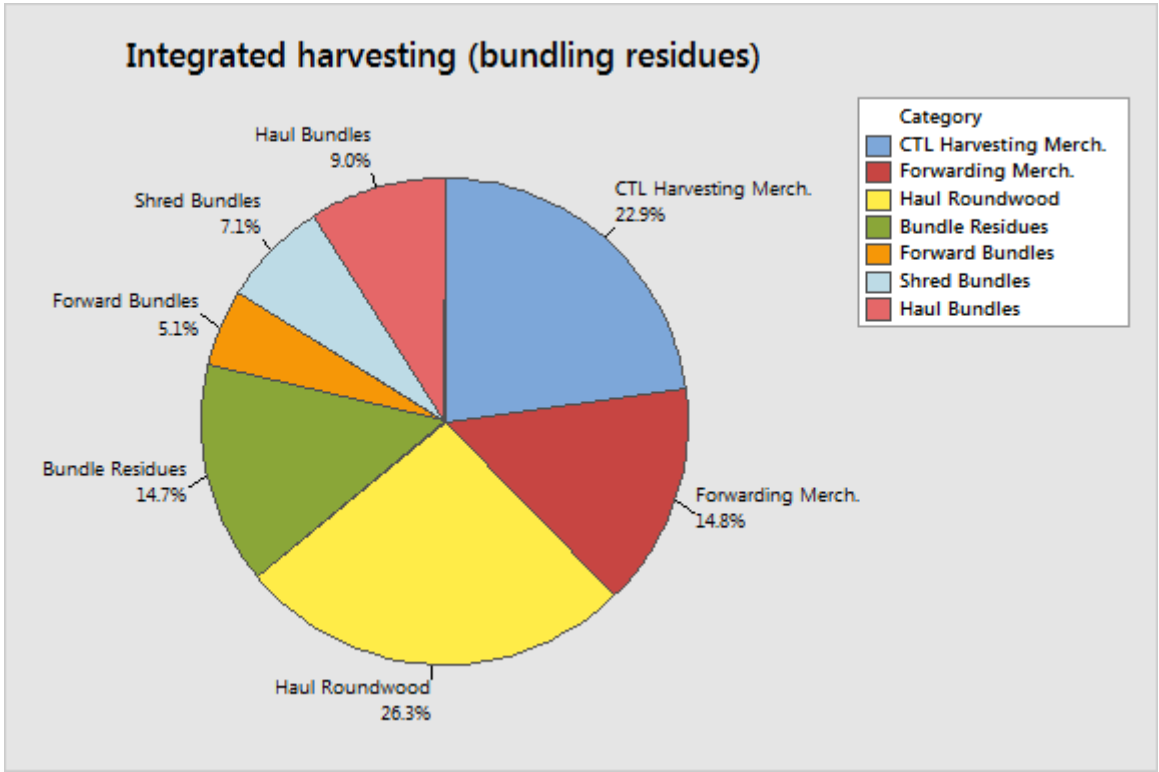
Value of products: Market Survey

Scenario:
YC: 10
Harvest Year: 15
Extraction Distance: 200 m
Haulage Distance: 50 km

Integrated harvesting (bundling residues)

| Merch. Volume / ha | Residues odt / ha |
|---|---|
| 258 | 36 |

| Operation | | Cost / ha € |
|---|---|---|
| CTL Harvesting Merch. | Y | 1744 |
| Forwarding Merch. | Y | 1129 |
| Bundle Residues | Y | 1123 |
| Forward Bundles | Y | 389 |
| Shred Bundles | Y | 542 |
| Haul Roundwood | Y | 2005 |
| Haul Bundles | Y | 688 |




Fuel Characteristics: Database

Value of products: Market Survey

Next: Include establishment and maintenance costs. Then evaluate the time cost

| | | | | |
|---|---|---|---|---|
| **Clearance** | | | | |
| Windrowing | 400 | ha | | |
| Vegetation Clearance | 42 | hour | | |
| | | | | |
| **Ground Prep** | | | | |
| Mounding | 390 | ha | | |
| Ripping | 250 | ha | | 250 |
| Ploughing | 150 | ha | | |
| | | | | |
| **Fertiliser** | | | | |
| Nitrogen | 330 | tonne | 250 kg per ha | 82.5 |
| Phospherous | 370 | tonne | 100 kg per ha | 37 |
| NPK | 400 | tonne | | |
| Application | 12.5 | 50 kg | | 87.5 |
| | | | | |
| **Plants and planting** | | | | |
| Plants* | 250 | 1000 | 2500 | 625 |
| Planting into mounds | 120 | 1000 | | |
| Planting beside rips | 130 | 1000 | 2500 | 325 |
| | | | | |
| **Fencing** | | | | |
| Stock | 3 | m | | |
| Sheep only | 4 | m | | |
| Stock and rabbit | 6 | m | | |
| Stock, rabbit and deer | 17 | m | | |
| Sheep and rabbit | 6 | m | | |
| | | | | |
| **Herbicide and cleaning** | | | | |
| Glyphosate | IFA | | | |
| Application | 120 | ha | | 120 |
| Cleaning | 130 | ha | | 130 |
| | | | | |
| **Pesticide** | | | | |
| Chemical cost | IFA | | | |
| Application | 140 | ha | | |
| | | | | |
| **Other maintenance** | | | | |
| Filling in | 57.5 | ha @ 5 % | | 57.5 |

Need fencing and roading

# Run analysis for NPV and Discounted cash flow