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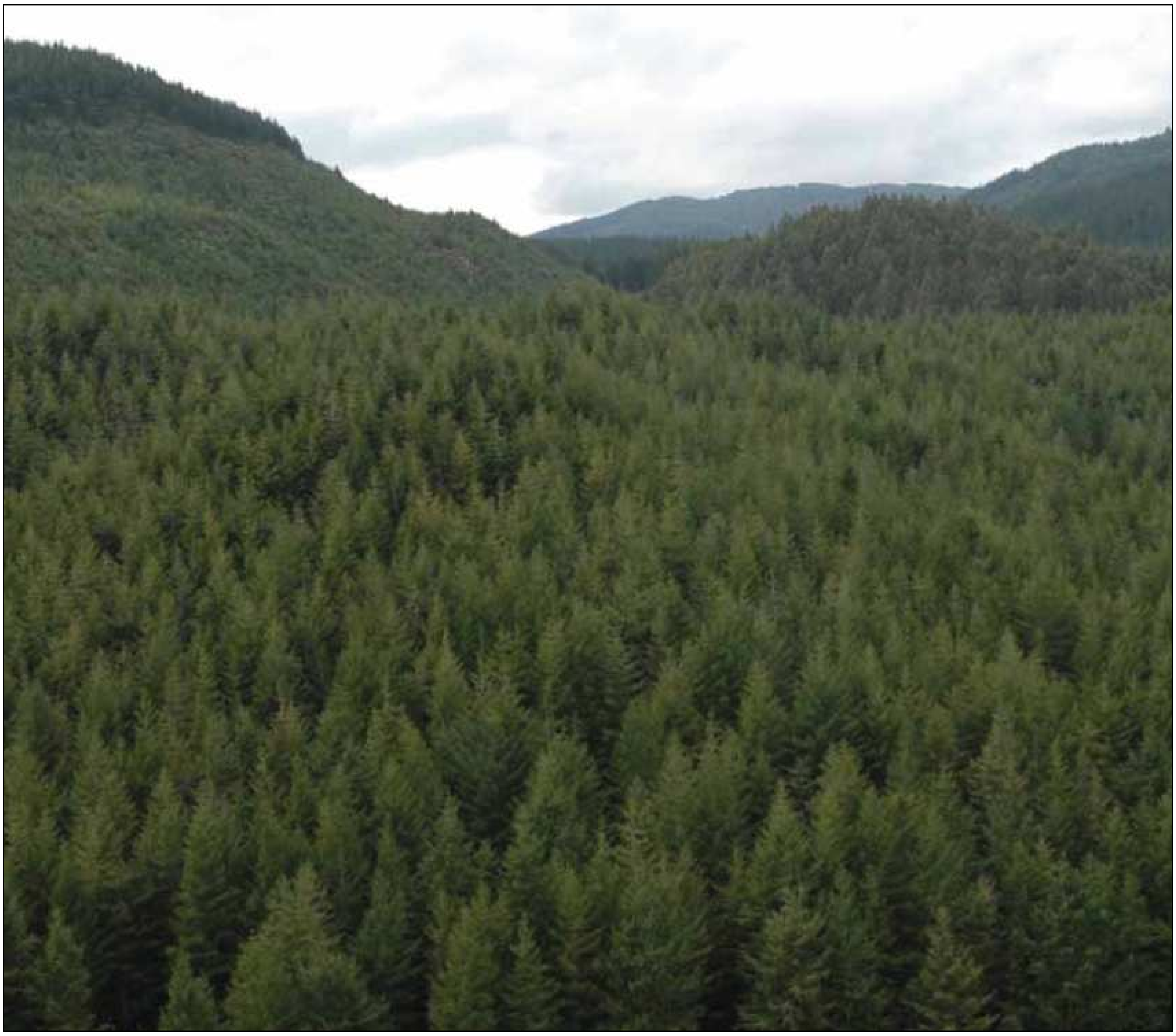
Volume and cost analysis of large scale woody biomass supply;

Southland and Central North Island



Report for the Parliamentary Commissioner for the Environment: 2010

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REPORT INFORMATION SHEET

REPORT TITLE	VOLUME AND COST ANALYSIS OF LARGE SCALE WOODY BIOMASS SUPPLY :
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SUMMARY

This report presents an analysis of the volume of woody biomass that could be supplied to sites at Mataura and Kawerau from the existing plantation forest estate for use in a biomass to liquid biofuels plant. The analysis includes residues and logs.

The outputs derived are a set of tables and graphs that present potential supply volumes for the sites for the years 2015, 2020, 2025, 2030, 2035, 2040 at cost limits of \$40, \$60 and \$85 per m^3.

The modelling takes forest data from the Ministry of Forestry National Exotic Forest Description and uses this in a Geographic Information System model (using the forest location and roading network) and determines volume by distance. This information is then joined with cost information derived from detailed costing spreadsheet models for transport and other costs.

The tables below show the maximum potential volume available at each location for each year and cost limit. These volumes include material currently being utilised by existing wood processing industries. All volumes are assumed to be potentially available.

Mataura: Maximum volume by cost limit and year, thousands of m^3 per annum

Cost limit	2015	2020	2025	2030	2035	2040
\$40	24	20	54	43	26	16
\$60	195	178	469	339	194	130
\$85	764	736	1,902	1,415	746	541

Kawerau: Maximum volume by cost limit and year, thousands of m^3 per annum

	2015	2020	2025	2030	2035	2040
\$40	164	168	249	255	171	83
\$60	1,435	1,703	2,449	2,390	1,755	960
\$85	4,721	5,653	8,971	7,866	5,968	3,314

Maximum transport distances for the set cost limits were reached at 80, 240 and 250 km for the cost limits of \$40, \$60 and \$85, respectively. These maximum distances are a function of the fixed cost of the wood and the variable cost of transport by distance.

Current market prices for logs, adjusted for transport distance, were used as they were assumed to be the best price indicator for non-residue wood supply.

Diesel consumption was found to be 5.23 to 5.53 litres per m^3 over an average transport distance of 85 km. Variable distance impacts on fuel consumption can be calculated using the equation below (where distance is in kilometres);

- Ground based harvest fuel use in litres per m^3 = 3.53 + (0.02*distance)
- Hauler based harvest fuel use in litres per m^3 = 3.83 + (0.02*distance)

Employment impacts were assessed and found to be limited as positive (increased residue harvesting employment) and negative (reduced log transport employment) balance out. Employment in forest harvesting will increase over time until 2025 to 2030, as the volume available for logging increases following the age class distribution of the plantation estate. After this the employment in this industry will drop as the harvestable volume drops.

The proportion of transport distances that could be achieved on private roads will vary with the total transport distance and with the region. At longer distances a lower percentage of transport will occur on private roads.

Due to the nature of some of the forest estates adjacent to Kawerau (large, mature and designed to supply multiple wood processing facilities at the Kawerau industrial site) a much higher percentage of the transport distance could be completed on private roads than in Southland.

In both cases (Southland, Mataura) and (Central North Island, Kawerau) there is a peak in volume supply around 2025 to 2035 due to the age class distribution of the forests. In order to maintain the peak volumes post 2025 new plantings would be required, and in order to mature in time these would have to be either short rotation forests (eucalypts or softwoods) or short rotation coppice based on willows.

The potential for short rotation forests and coppice crops to produce additional supply within the target regions was also assessed.

INTRODUCTION

The Parliamentary Commissioner for the Environment (PCE) commissioned Scion to determine the volume of woody biomass that could be supplied at a range of costs to two key sites identified by the PCE; in the Central North Island (Kawerau) and Southland (near Mataura).

The goal of the study is to determine the volume of biomass by costs ($40, $60 and $85 / m^3) that could be delivered to the selected site(s) in the years 2015, 2020, 2025, 2030, 2035 and 2040. Transport costs are based on the assumption of a truck transport system with a 53 tonne (PCE specified) gross vehicle mass (tare weights, payloads, fuel consumption derived from NZFOA 2007 and other industry information).

Biomass supply is based on the expected potential harvest from the existing plantation forest estate, its location, species, yield and age class distribution (MAF 2009, National Exotic Forest Description (NEFD) as at April 2008). Volumes are reported as cubic metres (m^3). One m^3 is approximately equivalent to 420 kgs of oven dry (od) wood.

Scion used its GIS based biomass supply model to determine the volumes of logging residue, chip logs and other woody biomass that are available as a function of distance from the selected site(s). A recently redeveloped harvesting and transport production and costing model (Hall 2009, unpublished data) was used to generate biomass supply costs, including transport cost regressions. The volume by distance, harvesting and cost by distance data were combined to produce volume by distance curves at three set costs; $40, $60 and $85 per m^3.

The report also includes calculations on the amount of diesel fuel used within the supply chain.

The proportion of transport that would be on private/public roads was estimated.

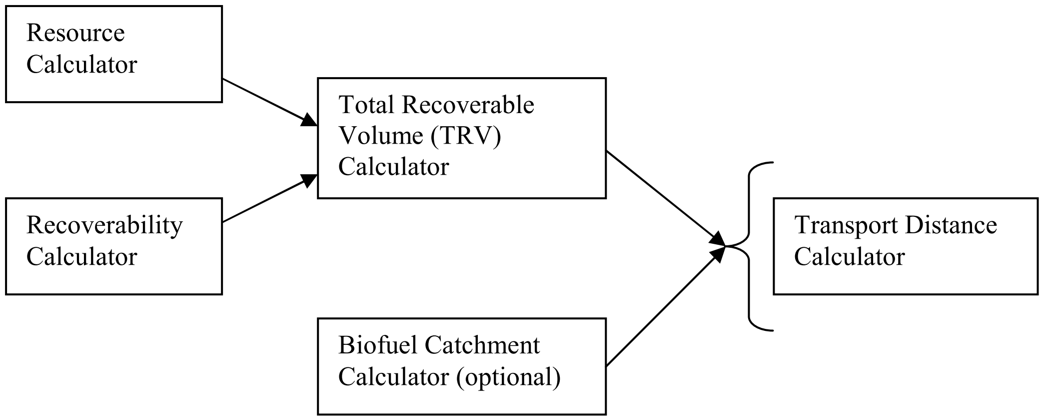
Estimates of the potential for supply of woody biomass from short rotation coppice (SRC) in the Lake Taupo basin and in Southland are included.

Estimates of potential changes in numbers employed in the supply chain are included.

GIS model

The biomass supply model (Hock et al, in prep.) has been implemented in ArcGIS 9.3 using Spatial Analyst and Model Builder. The toolbox “NZ Biomass model” contains five tools or “calculators” (Figure 1).

Figure 1 – outline of GIS biomass supply model



The biomass supply model can be run for a variety of scenarios: different years and hence different resource availability due to the age class distribution of the forest resource; different destinations (sites that have a demand for biomass such as cogen facilities at processing plants); and with or without competition between destinations. The output of the model is volumes of biomass a function of transport distance.

In this case two non-competing destinations were modelled (Kawerau (Central North Island) and Mataura (Southland)). The age class distribution data in the NEFD allows the model to be run for periods in the future. Once the total potential volume by distance is derived (via age class, location, regime and yield) various factors can be applied to determine volume by cost. These factors include; harvesting type (ground-based or hauler which is driven by slope), percentages of the crop expected in differing log-grades (prices) and the transport cost by distance. The model uses the existing roading network and chooses the shortest route. In the case of a first rotation forest with no current road access the model connects the forest to the road network via the shortest distance. This is more likely to occur in Southland, due to the different maturity of the respective forest estates.

Costing models

The costing models are a set of Excel spreadsheets that are used to estimate;

- forest growing costs
- roading costs (in-forest access)
- hauler and ground based logging system productivity
- logging system costs
- transport costs (variable by distance)

Much of the costing calculators used in the logging and transport system costs are derived from the LIRO Business management for logging handbook (Riddle 1994, Blackburn 2009).

The outputs of the various calculations are used to derive a cost per m^3 or oven dry tonne (odt) by distance. Cost assumptions used are provided in appendix one. An example of a logging system costing is provided in appendix two.

The distance from the delivery point is determined by the GIS model. The cost of delivery was calculated subsequently. When the cost limits was reached it was assumed that no further volume is available.

Costs – growing, harvesting and transport

Indicative delivered log price ranges from 2009 are provided in Table 1 (Agrifax, 2009).

Table 1 - Indicative delivered log prices.

	P1	S1/S2 long	L (K)	Pulp
BOP	130-140	85-90	61-68	45-59
Tauranga	118-123		61-68	46-50
Southland	122-128	70-76	50-56	37-40

Costs for the regions in the study were derived using site specific assumptions; with transport costs based on revised (53 tonne GVM) transport regulations.

A single tree or stand of trees will have a mix of grades within it, depending on the management regime. Some typical out-turns (as a % of the crop) are provided below;

	P	S	L (K)	Pulp
- pruned regime	20 to 25%	40%	20%	15 to 20%
- unpruned regime	0%	55 to 60%%	25	15 to 20%

Growing costs (see Appendix 3 for costing example)

- CNI $24.68 per m^3 (average yield of 704 m^3/ha)
- Southland $36.77 per m^3 (average yield of 520 m^3/ha)

Log harvesting costs
Hauler (motor manual) = $35.26 per tonne

For both the regions the hauler costs are estimated to be the same. The terrain and soil type do not have a significant effect on hauler production

Ground-based (mechanised)

- CNI = $27.80
- Southland = $30.72

For the ground based harvesting systems, the soil and terrain conditions are likely to result in slightly lower production in Southland than in the CNI. Southland soils are heavier and less well drained the predominantly pumice/volcanic soils of the CNI. This results in lower traction/payloads for extraction machines.

Transport costs

Transport costs were calculated on the basis of using vehicles with a 53 tonne gross vehicle mass (GVM). This gives a 36 tonne log payload. This is higher than the current 44 tonne GVM / 29 tonne payload limits. The 53 tonne GVM is expected to be possible under new regulations in the future, use of this assumption was at the request of the PCE.

Transport cost regression for log trucks at 53 tonne GVM; $y = -0.0254\ln(x) + 0.3038$, where y= $per tonne per kilometre and x = the transport distance in kilometres. For example, 75 km haul distance, = $0.194 per tonne per kilometre or $14.55 per tonne. Costs by Distance are presented in Table 2

Table 2 - Log Transport cost table

Distance, KM	$per t per km	$ per t
10	0.25	$2.45
20	0.23	$4.55
30	0.22	$6.52
40	0.21	$8.40
50	0.20	$10.22
60	0.20	$11.99
70	0.20	$13.71
80	0.19	$15.40
90	0.19	$17.06
100	0.19	$18.68
110	0.18	$20.28
120	0.18	$21.86
130	0.18	$23.42
140	0.18	$24.96
150	0.18	$26.48
160	0.17	$27.98
170	0.17	$29.47
180	0.17	$30.94
190	0.17	$32.40
200	0.17	$33.84

Residue harvesting costs

A proportion of the traditional forest harvest is currently left in the forest as it has no market. This material can be categorised as landing residues and cutover residues. Landing residues are material from stem to log processing, where stems are cut into logs and short sections of low value or defective material are cut out of the stem and discarded. This is done to maximise the value recovery from the stems, by focussing on producing as much higher value material as possible. The log sections produced are often short (0.1 to 2.0 m) and difficult to handle with machines configured to handle logs of 2.5 m plus in length. There are few markets for this material and often it is abandoned in the forest. It is a potential energy resource. The proportion of material that is wasted varies with crop type, harvesting system and operator skill and can be between 1 and 12 %, although typically it is between 4% and 6 %. For landing residues in this study figures of 5% and 6% were used for ground-based and hauler respectively.

Cutover residues are available from the felling site (from ground-based harvesting operations). As trees are felled there is a proportion of the stem and crown that is broken into short, often unmerchantable sections. This material also contains the crown or branch material, which is concentrated in the upper third of the stem, where most of the felling breakage occurs. This material also varies with crop, harvest system and operator skill but is typically in the order of 50 to 100 cubic metres per hectare. Usually this material is left on site as there is no market for it, but it is suitable as an energy resource. Here we used $50m^3$ per hectare for ground based cutover. No cutover residue was assumed to be taken from hauler operations.

Harvesting cutover residues from flat or rolling terrain does occur in some instances; for example Kinleith forest, where the material is used as boiler fuel at the Kinleith pulp mill near Tokoroa.

Harvesting of cutover residues from steep terrain is not considered to be financially or environmentally viable. The extraction costs would be at least \$45 to \$50 per m^3 (not including transport), and removing all the residual biomass from a steep slope could pose a risk of accelerated erosion.

Estimated harvesting costs for these residual materials from forests are presented below.

Landing residues;

Raw material cost	\$10.00
Loading	\$ 5.78
Transport (75km)	\$17.74 (\$/t/km = -0.0312*Ln(km) + 0.3713)
Screening	\$ 8.76
Total	\$42.28 (\$24.54 excluding transport)

Cutover residues;

Raw material cost	\$ 7.00
Forward (extract)	\$14.61
Loading	\$ 5.78
Transport (75km)	\$16.56 ((\$/t/km = -0.021*Ln(km) + 0.3465)
Screening	\$ 8.76
Total	\$55.71 (\$39.15 excluding transport)

Residue transport costs

The log transport cost regression used was \$/t/km = -0.02554*Ln (km) +0.308. Note; transport costs do not include loading and unloading machine costs, but do include the time the truck spends waiting. The costs of the loading machine are included in the logging costs and unloading is assumed to be part of the conversion plant operation cost.

The variation in transport costs between the two different residue harvesting systems is due to differing assumptions about the transport logistics. The landing residues are assumed to be placed into set-out bins during the forest harvesting operation. The bins are then collected by a truck fitted with a hydraulic hook to pick up the bins. The cutover material is loaded in conventional high volume bin trucks, which have a lower tare weight and therefore slightly higher payload.

The reason for the different transport systems is driven by trying to get the best fit with the log harvesting operations. In the case of landing residues, the machinery already on-site is utilised to handle the material and load it into the bins, recovering it efficiently without interfering with log harvest production. Cutover residue recovery operations can be done post harvest (to enable air drying) and different systems are appropriate.

Cost summary

Table 3 - Cost estimate summary ($ per tonne) for log supply

	CNI Hauler	CNI Ground-based	Southland Hauler	Southland Ground-based
Growing	24.68	24.68	36.77	36.77
Logging	35.26	27.80	35.26	30.72
Transport (75km)	14.55	14.55	14.55	14.55
Total	74.49	67.03	86.58	82.04

The costs in the summary table (Table 3) are all higher than the market price that is paid for pulp logs. Thus pulp logs are sold at a loss, but as they are grown and extracted along with the higher value material and are available at the landing irregardless, they do represent a real revenue stream to forest growers. Growing costs were estimated using the template in Appendix 3. Southland growing costs are higher due to lower final crop yields.

Note: the costs presented here use a fixed transport distance of 75 km, to give an indication of delivered costs. The volume by distance curves use the distance based cost regression to generate transport costs.

The log prices suggested for the logs by the costs in Table 3 give pulp log prices that are too high (especially for Southland) compared to current log market prices. This highlights the discrepancy between what it might have cost forest growers to produce a log, and what they might actually get paid. If the price is low then the return on investment shrinks, but as the material is mature and available, in some cases harvest will occur anyway.

On average forest growers need around $75 to $85 per cubic metre for every cubic metre harvested. However, in the real market, some logs sell for more and some sell for less, with the return on better quality logs effectively subsidising the lower value product. Therefore, it was considered that a more accurate indicator of the likely log price paid was the current market, and the log prices used are based on the data presented in the February 2010 Agrifax Regional log price and cost report (summarised in Table 4). The exception to this is the costing of the production of logging residues, there is little in the way of an established market price for this material so a cost estimate was used.

Residue raw material prices, as on the previous page, $10 per tonne for landing residues and $7 per tonne for cutover residues. The cutover residues have a lower price as they will be expensive to recover. The cost of recovery and transport has to be added to the raw material cost to get to a delivered cost.

Table 4 – log prices ($/tonne) used in all subsequent calculations

Pulp	50
L (K) grade	69
S grade	90

The prices in table 4 apply regardless of region or harvesting type.

In order to determine the impact of transport distance, the mean transport distance incorporated the log prices above was removed and replaced with a cost by distance calculation.

Supply volumes

Supply volumes were derived from the National Exotic Forest Description (NEFD; MAF, 2009). The NEFD figures provide age class, area, species and yield data by territorial authority. These tables are used in the GIS model to determine volumes available.

As a cross check on the volumes produced by the GIS model, the total recoverable volume for the Otago / Southland and Bay of Plenty regions are provided below (Figure 2 and 3), to give an indication of the gross harvestable log volume (not including residues) over time.

Figure 2 – total recoverable log volume for Otago / Southland, m^3 per annum

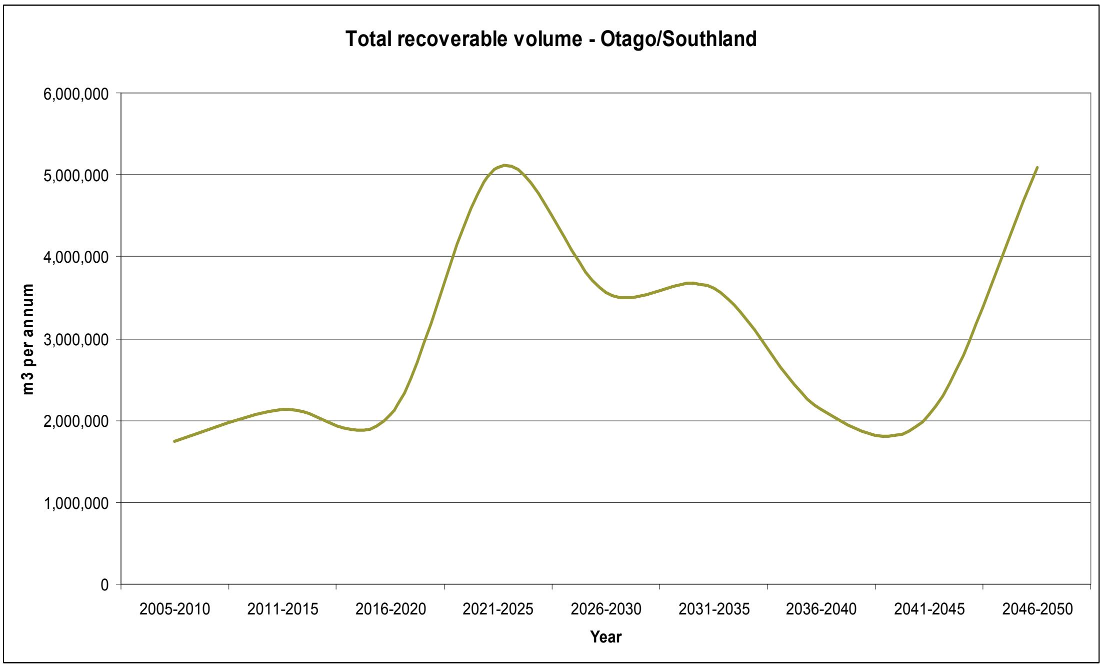
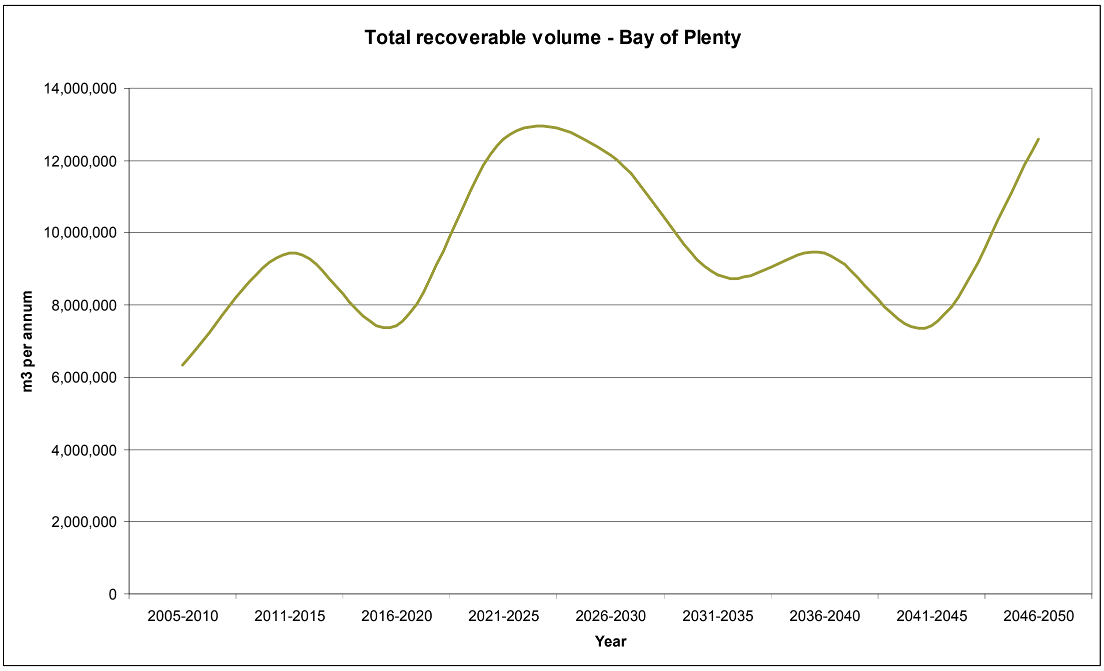


Figure 3 - recoverable log volume for Bay of Plenty, m^3 per annum



The fluctuations in recoverable volumes are due to the age class distribution of the plantation estate. Both these regions (and national figures) show a peak of log volume being available around 2025 to 2030. This is due to large areas of forests planted during the 1990's becoming mature. This fluctuation in potential volume availability should be considered in any utilisation decisions. However, the harvesting peak volumes indicated in the graph may not occur. As forests are flexible in their harvest date (by several years) some smoothing of the peaks (especially for Southland) is likely, by delaying harvest of some stands.

Where the peaks and troughs in supply from the existing forests estate are severe, consideration could be given to smoothing the wood flow by establishing new alternative supply. Given the time frame and the typical rotation length of plantation forests (25 to 30 years) use of short rotation coppice (3 to 4 years) and short rotation forests (12 to 16 years) is an option.

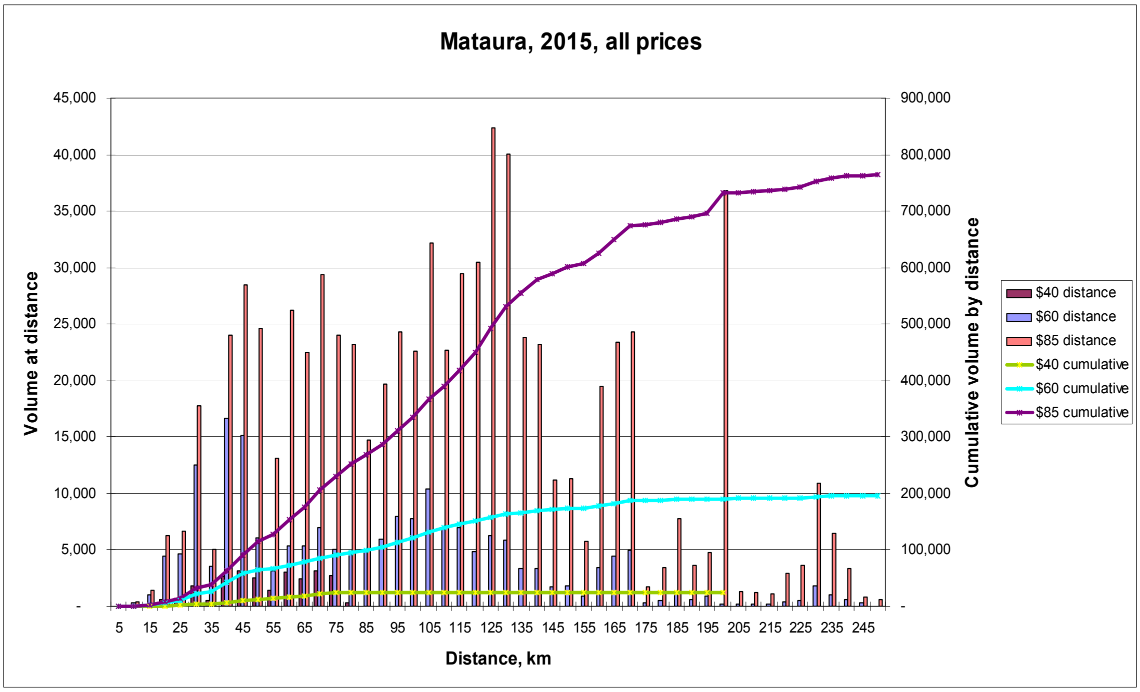
Volume by distance curves - by upper cost limit

Volume by distance curves are derived from the GIS model. Log growing, harvesting and transport costs are then applied to develop a volume that is available by distance which is under the cost limits set. Any material that is more expensive than the selected limits is excluded from the available volume. All the graphs are presented as Volume available at a distance (columns, left hand scale) and cumulative volume available at a distance (lines, right hand scale). Each graph has 3 cost limits, \$40, \$60 and \$85 per m^3, which effectively limit the volume that can be obtained.

Tables for the data presented in figures 4 to 15 are presented in Appendix 6.

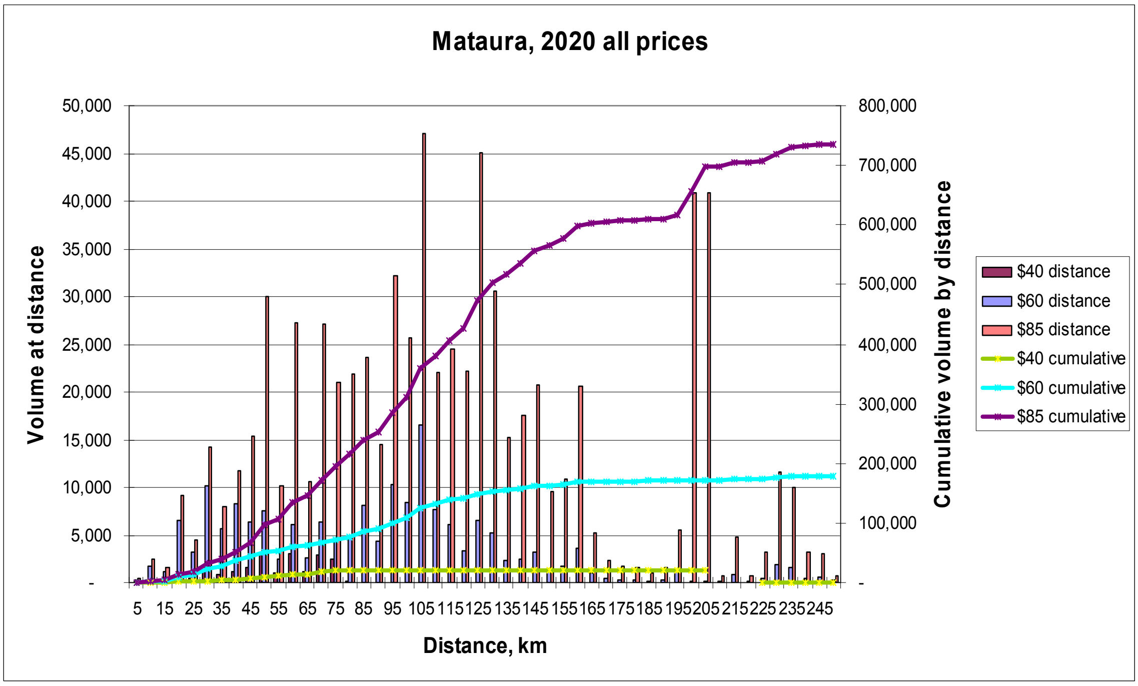
Southland - Corner of SH1 and Glencoe Highway, south of Mataura township.

Figure 4 – Volume (m^3 per annum) by distance, and cumulative volume by distance, Mataura, all price limits, 2015



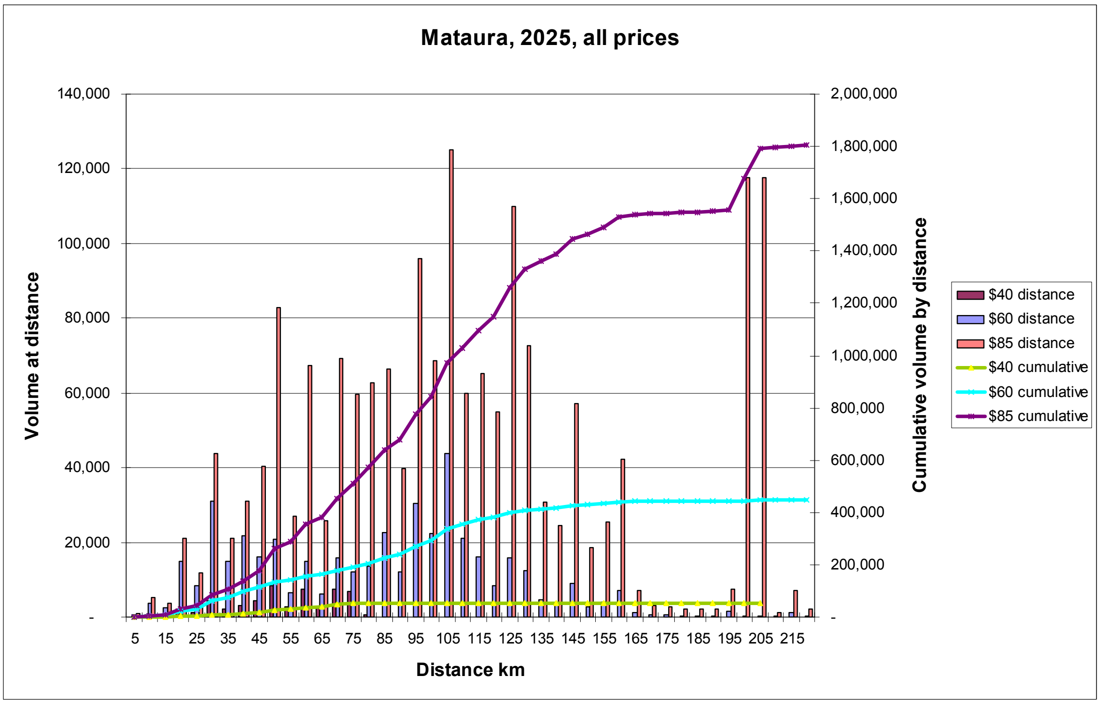
For the Mataura site in 2015 the maximum volumes available at \$40, \$60 and \$85 per m^3 are 24,000, 195,000 and 764,000 m^3 per annum respectively.

Figure 5 - Volume (m^3 per annum) by distance, and cumulative volume by distance, Mataura, all price limits, 2020



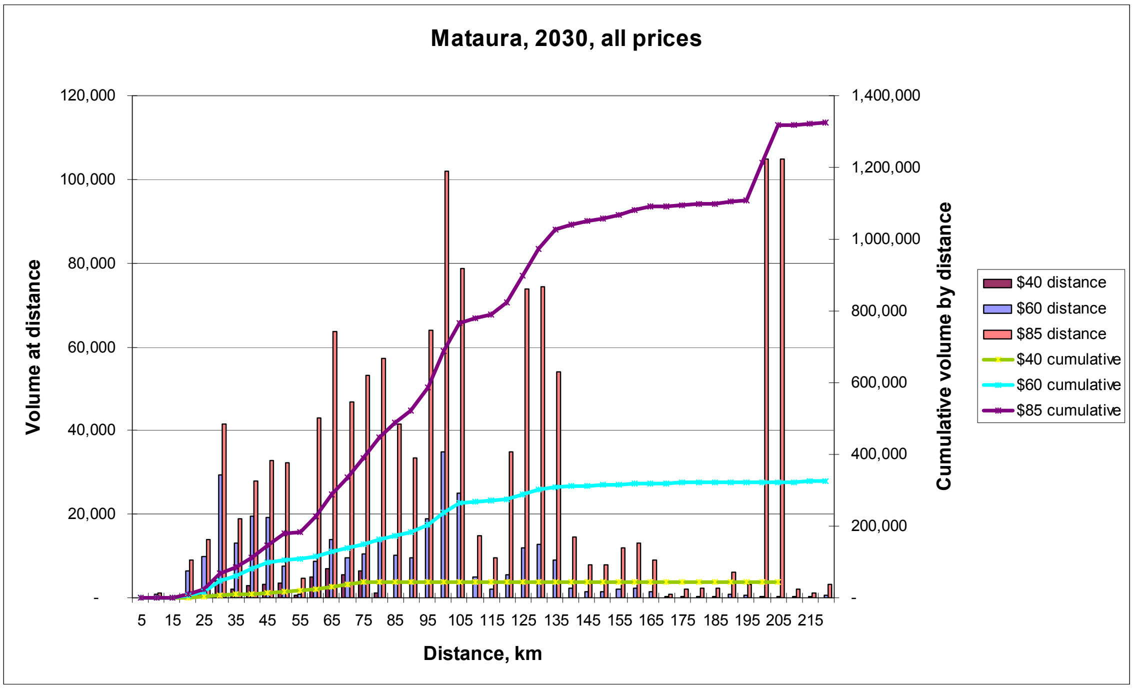
For Mataura in 2020, maximum volumes are;
$40, 20,000 m^3 per annum
$60, 178,000 m^3 per annum
$85, 736,000 m^3 per annum

Figure 6 - Volume (m^3 per annum) by distance, and cumulative volume by distance, Mataura, all price limits, 2025



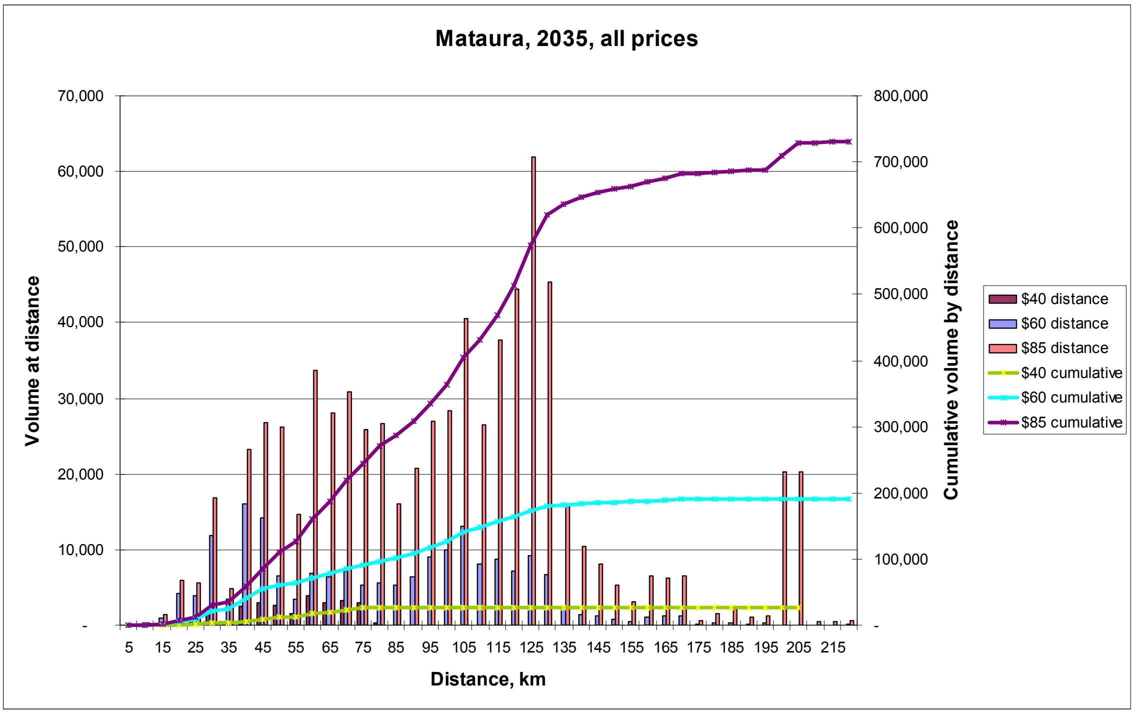
For Mataura in 2025 maximum volumes by cost are 54,000, 469,000, and 1,902,000 m^3 per annum for \$40, \$60 and \$85 per m^3 respectively.

Figure 7 - Volume (m^3 per annum) by distance, and cumulative volume by distance, Mataura, all price limits, 2030



The maximum volumes for Mataura in 2030 are slightly lower than 2025 at \$40 43,000 m^3 per annum, \$60 339,000 m^3 per annum and \$85 1,415,000 m^3 per annum.

Figure 8 - Volume (m^3 per annum) by distance, and cumulative volume by distance, Mataura, all price limits, 2035

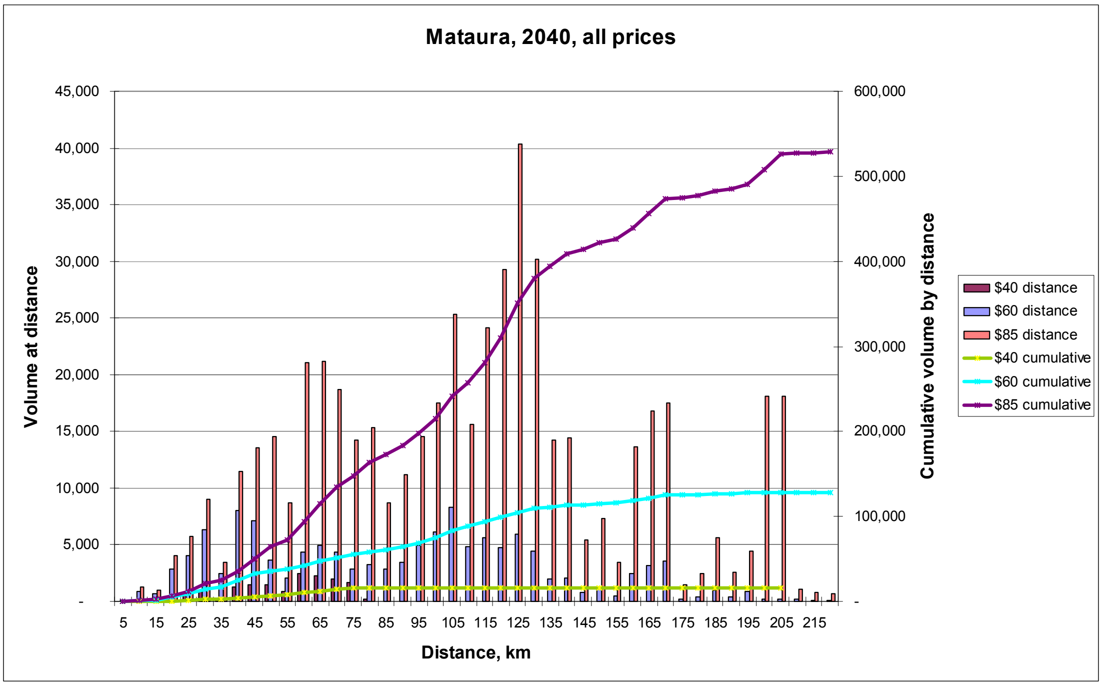


For 2035 and 2040 the maximum volumes are lower again.

For 2035;
$40, 26,000 m^3 per annum
$60, 194,000 m^3 per annum
$85, 746,000 m^3 per annum

And for 2040;
$40, 16,000 m^3 per annum
$60, 130,000 m^3 per annum
$85, 541,000 m^3 per annum

Figure 9 - Volume (m^3 per annum) by distance, and cumulative volume by distance, Mataura, all price limits, 2040

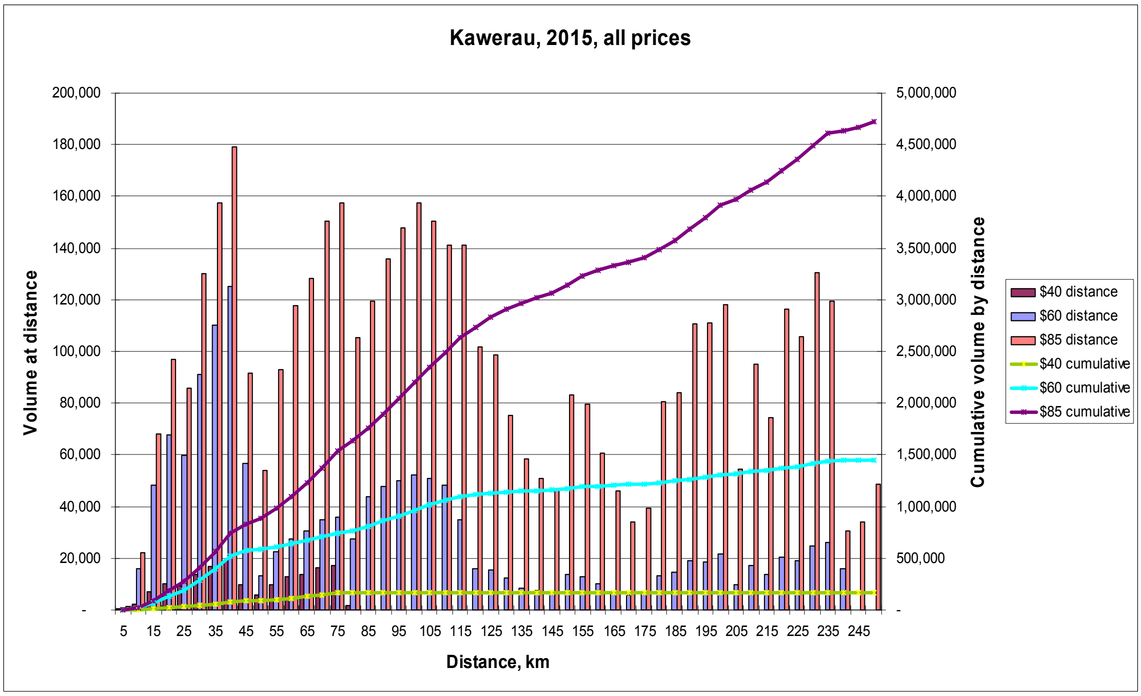


In all cases there are substantial increases in potentially available volume when moving between the various cost limits.

At $40 per m^3 the volume is largely limited to landing and cutover residues. At $60 per m^3 large volumes of pulp logs (15 to 20%of the crop) become available as well. At $85 L and K grade logs are added to the residual and pulp log volumes and the limiting factor is the cost of transport. These trends also apply to the Kawerau / CNI site.

Central North Island – Kawerau Pulp Mill access road entrance over-bridge, crossing SH 34, North east of Kawerau township.
The volumes available in Kawerau are higher than for Mataura, which is a reflection of the larger and more mature forests roading and infrastructure in the CNI. The Kawerau site also has peak in harvest volume in 2025 to 2030.

Figure 10 – Volume (m^3 per annum) by distance, and cumulative volume by distance, Kawerau, all price limits, 2015



Maximum volumes for Kawerau in 2015 for $40, $60 and $85 are 164,000, 1,435,000 and 4,721,000 m^3 per annum respectively.

For 2020 the maximum volumes are;
$40, 168,000 m^3 per annum
$60, 1,703,000 m^3 per annum
$85, 5,653,000 m^3 per annum

Figure 11 – Volume (m^3 per annum) by distance, and cumulative volume by distance, Kawerau, all price limits, 2020

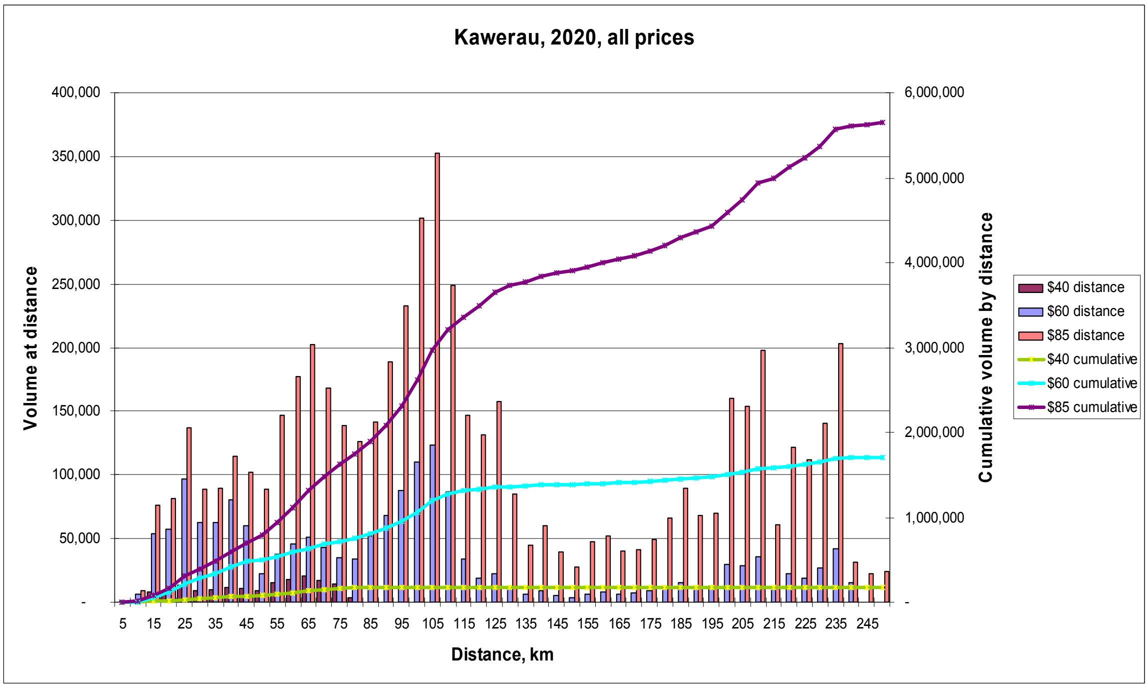
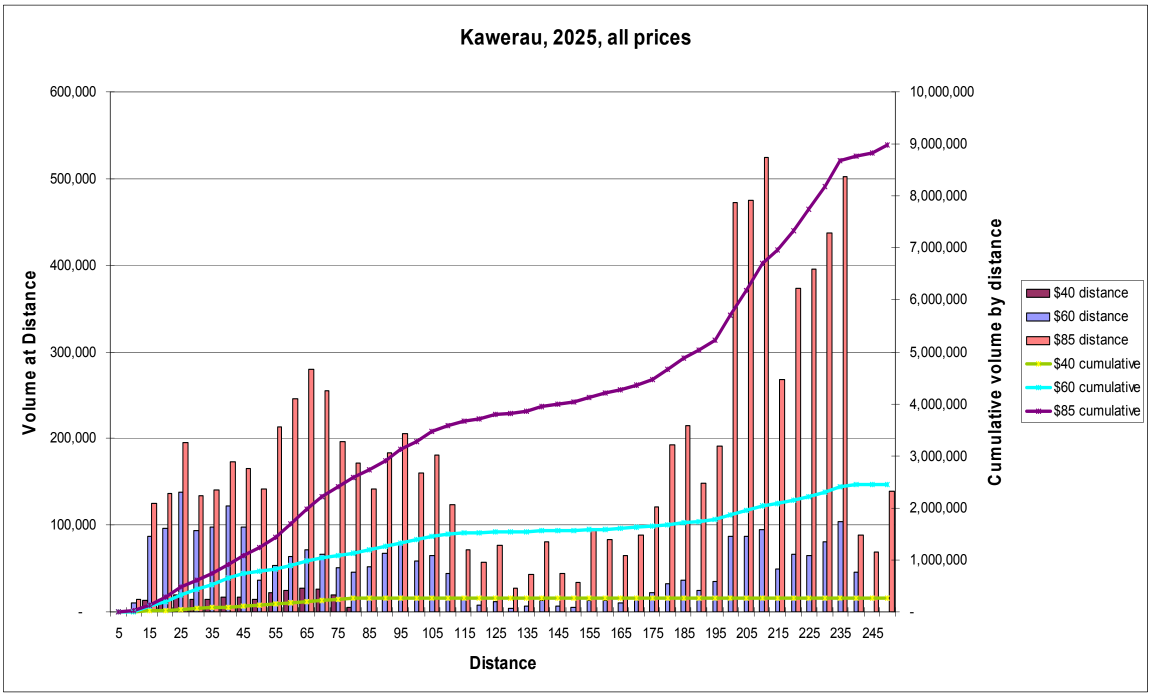


Figure 12 – Volume (m^3 per annum) by distance, and cumulative volume by distance, Kawerau, all price limits, 2025



For 2025 maximum volumes are;
$40, 249,000 m^3 per annum
$60, 2,449,000 m^3 per annum
$85, 8,971,000 m^3 per annum

For 2030 maximum volumes are very similar, but with a drop in the volume at the $85 cut-off;

$40, 255,000 m^3 per annum

$60, 2,390,000 m^3 per annum

$85, 7,866,000 m^3 per annum

Figure 13- Volume (m^3 per annum) by distance, and cumulative volume by distance, Kawerau, all price limits, 2030

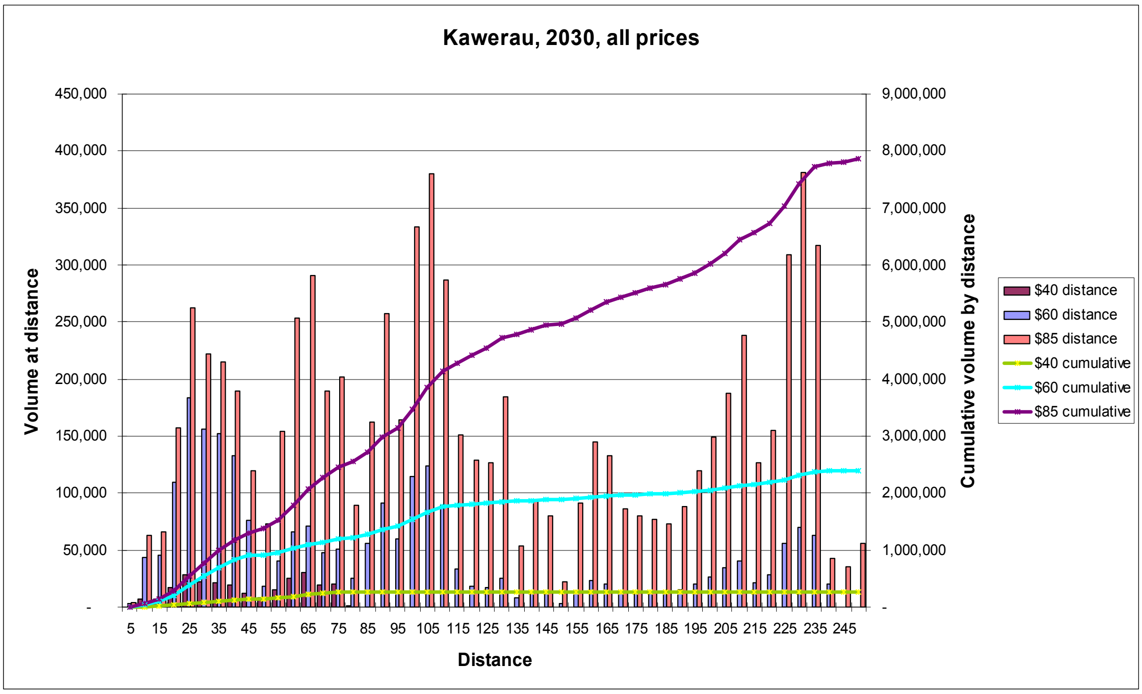
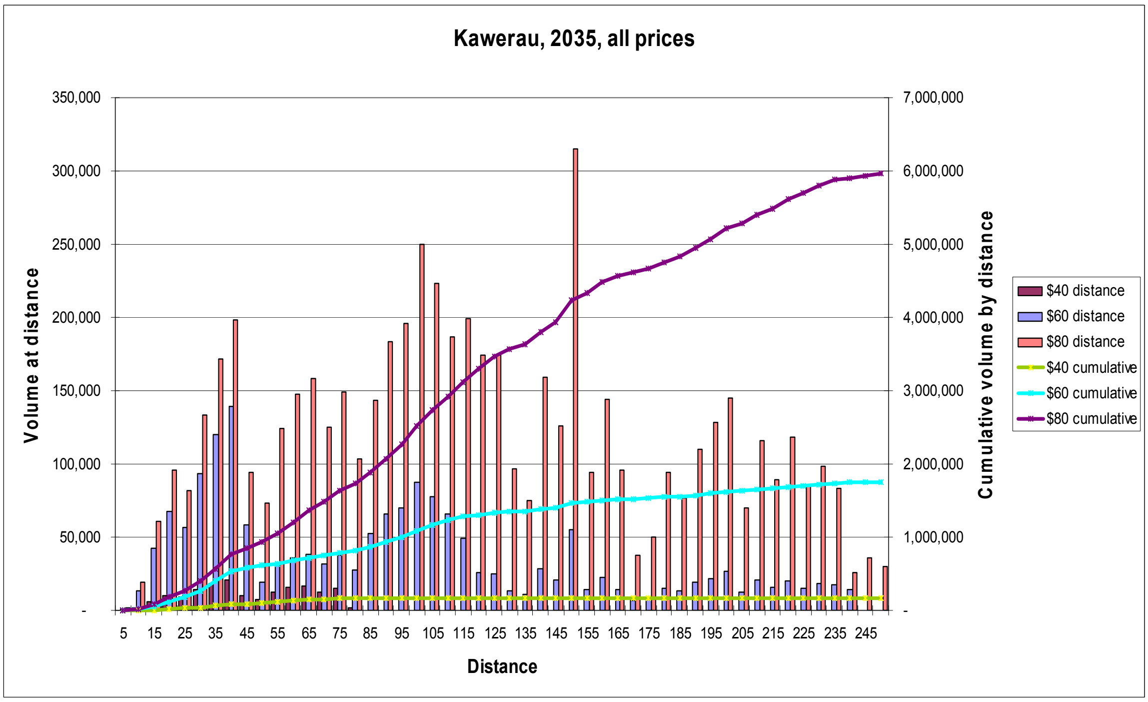


Figure 14 – Volume (m^3 per annum) by distance, and cumulative volume by distance, Kawerau, all price limits, 2035

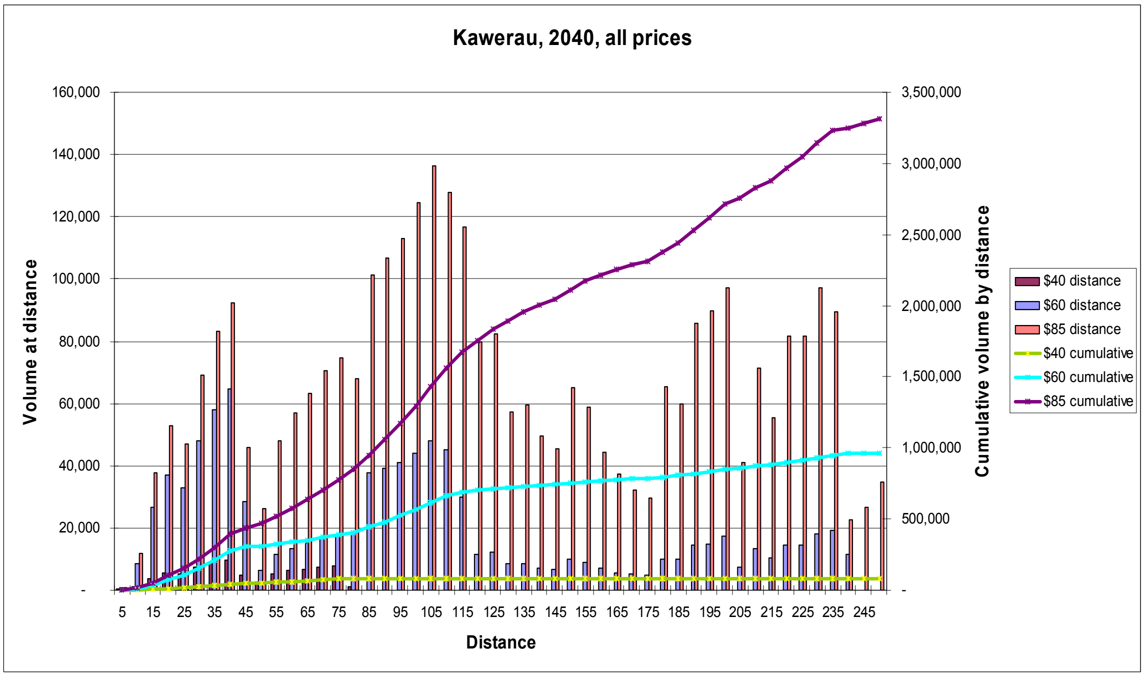


Volumes available drop in 2035 and further drops are apparent in 2040, across all cost limits.

For 2035 the maximum volumes are;
\$40, 171,000 m^3 per annum
\$60, 1,755,000 m^3 per annum
\$85, 5,968,000 m^3 per annum,

and for 2040 they are;
\$40, 83,000 m^3 per annum
\$60, 960,000 m^3 per annum
\$85, 3,314,000 m^3 per annum

Figure 15 – Volume (m^3 per annum) by distance, and cumulative volume by distance, Kawerau, all price limits, 2040



The analysis showed that the distances where the cost limits restrict volumes available vary slightly but are generally similar across both regions and cost limits;

Cost limit	**\$40**	**\$60**	**\$85**
Mataura	80 km	240-245 km	250 km
Kawerau	80 km	235-240 km	250km

Short rotation woody biomass - supply options

Introduction

As part of the biomass supply, short rotation coppice (SRC, 3 to 5 years) and short rotation forests (SRF, 12 to 16 years) crops were considered, with potential area and productivity being key parameters.

Central North Island and Southland SRC Productivity

Taupo

Concern has been expressed at the decline in water quality of Lake Taupo in the Central North Island of New Zealand. It is thought that the decline in quality is largely due to increased inputs of nitrogen from pastoral land. Investigations have been conducted into alternative land uses that will reduce environmental impacts on water quality. One such land use identified is growing willow for conversion to bioenergy and other products, for example ethanol and xylose with the production of bio-polymers from the by-product lignin stream.

Willow has been proposed for several key reasons:

- easy and cost efficient establishment
- vigorous early growth and ability to coppice (re-growth from the cut stump)
- efficient harvesting using continuous harvest systems
- potential for capital investment into a biorefinery
- good quality manufacturing, technology jobs
- direct use of geothermal energy (heat for drying and distillation) – relevant to CNI region generally and Taupo specifically

Within the Lake Taupo Catchment (348,700 ha), it is estimated (Royal Society of NZ, 2006) that 107,000 ha is suitable for SRC willow crops. However, some of this land is either high earning in its current agricultural use, or already afforested. When high earning land (>$350 per ha per annum) and existing forests are excluded, it is estimated that ~24,000 ha is suitable and potentially available for SRC willow.

Willow trials

In 2004 a small (2 ha) demonstration trial was established on Hauhangaroa 2C Maori Trust land to the west of Lake Taupo. This aimed to give an early indication of establishment issues and provided a demonstration site for potential stake holders (Figure 16). In 2005 a larger (4 ha) trial was established just North of Taupo (Figure 17 and 19).

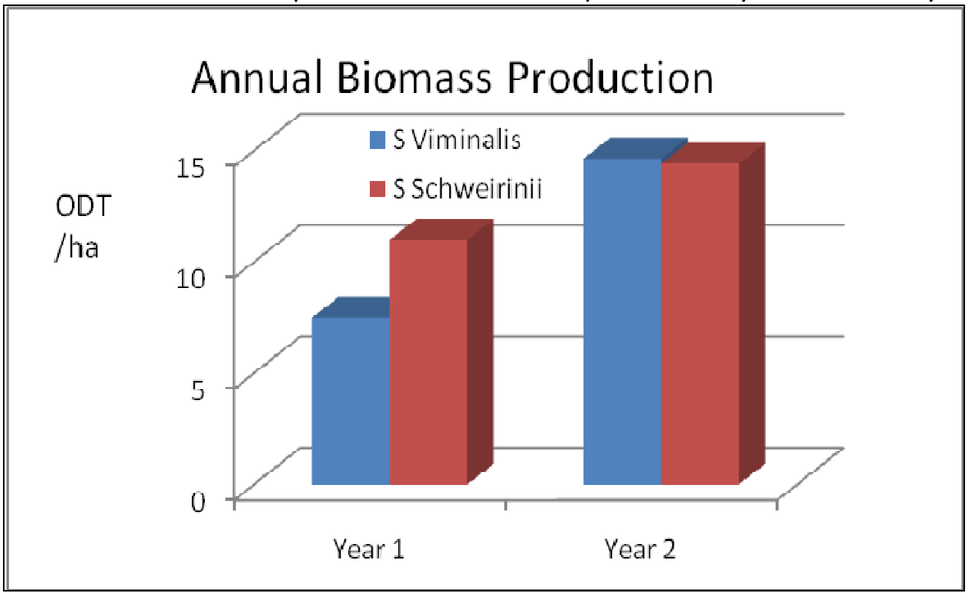
Figure 16: Demonstration willow plantation age 4 years Central North Island

Figure 17: Site preparation before planting at the main Taupo trial.

Figure 18: The same area as Figure 2, one year after planting.

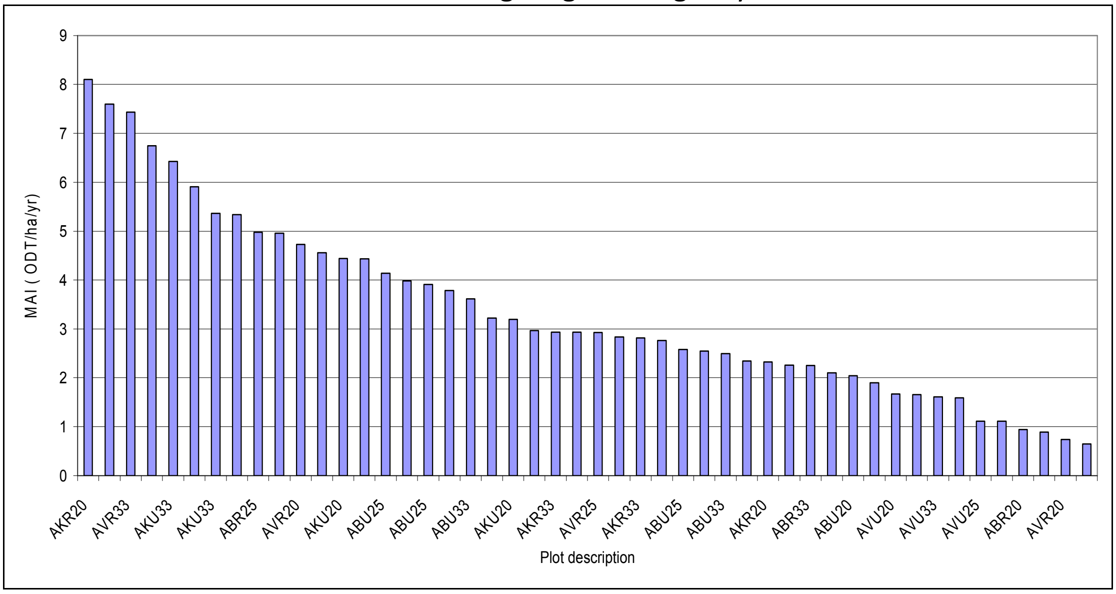
The Western Bay demonstration planting was coppiced at age three years and biomass data collected off the *Salix viminalis* and *Salix schwerinii* regrowth. The greatest biomass was accumulated by *Salix schwerinii* after two years growth, though much of this advantage appears to have occurred in the first year of the cycle (Figure 19). That may be due to improved ability to handle drought, whether physiologically or earlier growth during good growing conditions.

Figure 19: Annual biomass production from two species on 4 year old root systems.



Data from the larger trial show a range in annual productivity from over 8 odt/ha/yr down to one odt/ha/yr from plots suffering severe drought because of shallow soils in one part of the trial (Figure 20). This trial had gone through a dry period in the growing season before harvesting which may have reduced yields. At age three years there were no significant differences between treatments (willow species, site preparation, and cutting length).

Figure 20: Individual plot data covering three willow species, site preparation and different cutting lengths at age 3 years.



Based on data from both trial areas the willow handbook (Snowdon et al. 2008) used 10 odt/ha/yr as a basis for willow productivity.

If 24,000 ha of SRC willow was established in the Lake Taupo catchment, given the expected productivity above (10 odt per annum times a 3 year rotation = 30 odt per ha at harvest) the harvestable volume off one third of the planted area (assumes a 3 year rotation) would be ~240,000 odt per annum. This material includes bark as well as wood, but not leaves. The presence of bark is a factor to consider in some biomass to energy conversions as bark may be unsuitable for some bio-chemical processes. However, it is less likely to be an issue in thermo-chemical processes.

Rotorua Opportunities

Rotorua has similar land use issues to Taupo (driven by lake water nutrient levels) and many of the drivers for a biofuel project are the same. Rotorua is within the biomass collection catchment of the proposed Kawerau biorefinery, and could be used to provide raw material to such a plant. However, the Lake Rotorua water catchment is much smaller than Lake Taupo's (around 43,700 ha) and much of the land is steep to rolling limiting the area available for SRC crops. At most around 5,000 ha might be available for SRC (yielding 50,000 odt per annum).

On the positive side land in the Rotorua catchment is much closer to Kawerau than the Taupo catchment.

Eucalypts in the Taupo catchment.

A central North Island resource of eucalypts for short fibre pulp of approximately 12,000 ha was established by Tasman Forest Industries from 1994. Previously nearly 7,000 ha of eucalypts for short fibre pulp had been established by Forest Products Ltd.

The total eucalypt plantation resource in New Zealand is approximately 25,000 ha, with 12,800 ha of this in Southland, mostly in the *E. nitens* estate of Southwood Exports, grown on a 14 to 16 year rotation.

There are 9,800 ha of Eucalypt plantations in the CNI region, of mixed species. The sale of Tasman Forest Industries to GSL Capital Ltd in 1999 halted the development of the eucalyptus establishment programme in the CNI. The majority of the short rotation eucalypt plantings in the CNI are now being de-forested as they reach harvesting age (12-15 years), with many stands returning to pastoral land use, often dairying.

The viability of the medium rotation eucalypt approach is heavily influenced by species choice and correct siting. The E. nitens in the GSL Capital estate was largely a failure in the Central North Island due to defoliation by paropsis beetles and fungal attack. E. nitens in Southland (a cooler climate) appears to thrive and be a viable biomass crop (for example the Southwood Exports estate focused on hardwood chip production). However, some cooler sites in the CNI do show good production for E. nitens (Table 5) where Nicholas (2009) reported on temporary plots at Kinloch, near Taupo.

Table 5: Plot details of temporary eucalypt plots in 11 year old *E. nitens*.

	Stocking Live (total)	**MTD***	**MTH#**	**Crown ht**	**BA**	**Volume**	**MAI volume**
	Stems/ha	cm	m	m	m^2/ha	m^3/ha	m^3/ha/yr
Plot 1	850 (1025)	36.3	30.3	16.2	36.81	355.2	32.3
Plot 2	975 (1100)	34.8	30.9	18.4	41.71	410.2	37.3
Plot 3	1000	32.2	26.2	13.8	31.14	249.3	20.1

* Mean DBH of the largest diameter 100 stems/ha

\# Mean height of largest diameter 100 stems/ha

A nearby trial of *E. fastigata* at stockings over 2500 was producing over 30 m^3/ha/yr (15 odt per ha per annum).

Southland eucalypt and willow opportunities

The options for a dedicated bioenergy crop to supply 500,000 oven-dry tonnes of biomass in the Southland and Otago regions were assessed. The two main crops considered were eucalypt and willow short-rotation forestry plantations. Information on yields, costs, critical site factors and the areas required to meet the supply target were evaluated.

Syntheses of this data led to the conclusion that *Eucalyptus nitens* on a 15-year rotation was the preferred option because of its greater growth rate, wider site tolerance and lower delivered costs. Willow (*Salix viminalis* and/or *S. schwerinii*) on a 3-year rotation was also a viable option, especially on more benign sites. Additionally, it has the advantage of providing a biomass resource in a shorter time frame (4-5 yrs) from establishment compared to the eucalypt at 15-16 years. For E nitens it is estimated that an area of ~50,000 ha would be needed to provide an annual supply of 500,000 oven-dry tonnes. The willow option would require a similar land area.

Eucalyptus nitens is an established species in Southland, and there is over 10,000 ha established for export chip while the willow is still experimental.

Interpretation of Geographic Information System (GIS) maps incorporating climate (Figure 21) and slope suggest that, for these parameters, the land area potentially suitable for either crop could be in Southland (877,000 ha), Gore (114,000 ha) and Clutha (465,000 ha) districts to give a total of 1,457,000 ha (Table 6).

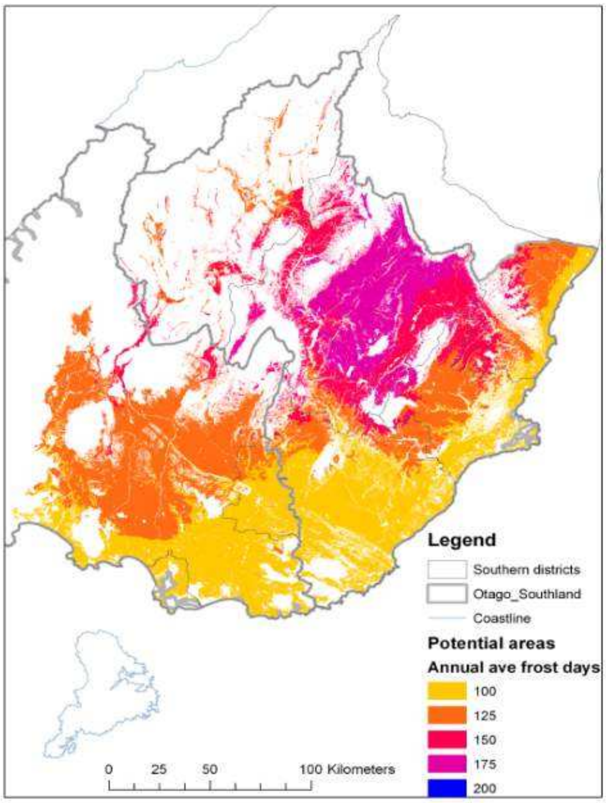


Figure 21 - Average annual frost days (slope <15^{O})

Table 6: Area (ha) within each frost zone, by region

	Frost-free days per annum				
District	100	125	150	175	Total
Central Otago District	4,025	33,384	241,665	294,337	573,412
Clutha District	363,175	87,090	14,970	539	465,774
Dunedin City	85,114	99,257	32,789	7,251	224,411
Gore District	92,296	21,791	39		114,126
Invercargill City	27,911				27,911
Queenstown-Lakes District	1,708	51,719	42,184	1,256	96,868
Southland District	318,964	525,964	31,760	736	877,424
Waitaki District	58,193	93,922	53,986	2,091	208,192
Total	**951,386**	**913,128**	**417,394**	**306,210**	**2,588,118**

The cost of the eucalypt material delivered to a plant (as logs) with an average transport distance of 75 km is estimated to be $75 per green tonne, with transport being $15 to $16 of this, supply would not begin before 2025.

SRC costs

Growing costs

$40.00 per green tonne (estimated - no confirmed NZ data)

Harvesting costs

$15 to $21 per green tonne, includes chipping cost (estimated- no NZ based harvesting productivity data)

Loading

$2.48 per tonne

Transport costs

Taupo to Kawerau	$0.199 t km	$35.82 per tonne (180 km)
Rotorua to Kawerau	$0.229 t km	$14.88 per tonne (65 km)
Southland to Matura	$0.222 t km	$18.65 per tonne (average 84 km)

Given the above costs, SRC material could be delivered in significant quantities for a cost of;
$76 to $82 per tonne in Southland,
$93to $99 per tonne in the CNI – Taupo basin origin (beyond the $85 threshold),
$72 to $78 per tonne in the CNI – Rotorua basin origin,

with supply beginning no earlier than 2014.

Employment

Employment in forest harvesting and services to forestry (including transport) totalled 5,820 in 2007 (NZFOA, 2009). The harvest volume in this year was 19 million m^3, giving an employment rate of 1 job per 3,300 m^3 of logs harvested.

Employment in forest harvesting would largely remain unchanged on a jobs per m^3 basis. Where the log material goes does not affect to how it is logged or how many people are employed. Changes in employment would be driven by increases in log harvest related to amount of forest available to harvest. There would be increases in both regions based on increased forestry activity, with the far greater increase in the Kawerau / CNI region.

Employment in transport would be lower per m^3 of log transported than it is currently. The existing road transport regulations limit trucks to a gross vehicle mass of 44 tonnes, which for logging trucks means a payload of around 29 tonnes. This study has assumed that transport will take place under suggested new weight limits of 53 tonnes GVM which would mean a payload of ~36 tonnes. This is an increase of 24%. The heavier trucks will be slower than is current but the impact of this will be limited as there are other components to truck productivity than road speed. Overall it is likely that employment in log transport would drop by around 20% on a per m^3 basis.

Assuming a 70 km average lead; transport employment would be 1 man / truck per 32,000 tonnes delivered.

Using actual average haul distance for material with cost limits;
$40, 85 km maximum, (56 km average), = 1man/truck per 40,000 tonnes delivered
$60, 215 km maximum, (129 km average), = 1man/truck per 17,000 tonnes delivered
$80, 250 km maximum, (167 km average), = 1man/truck per 13,000 tonnes delivered

Employment changes due to the establishment of an SRC/SRF resource are difficult to estimate, as there is an existing land use and employment (farming). The employment in SRF is likely to be more variable over time, with peaks at establishment and harvesting.

Clear employment increases would be driven by development of residue harvesting, which would create new jobs in the harvesting and transport of this currently unutilised resource. Employment rates are estimated to be;

- LR harvest 46,000 m^3 per man per annum
- LR transport 30,000 m^3 per man per annum
- COR Harvest 22,000 m^3 per man per annum
- COR transport 31,000 m^3 per man per annum
- Average 32,000 m^3 per man per annum

Table 7 - Total new employment by cost limit for selected years (nearest whole job)

	$40 per m^3			$60 per m^3			$80 per m^3		
Year	2015	2030	2040	2015	2030	2040	2015	2030	2040
CNI	9	12	5	29	43	19	49	70	30
Southland	2	3	1	5	9	4	6	10	4

The CNI has a greater potential to create new jobs due to its much larger forest estate and there is a peak around 2030, coinciding with the potential peak in harvest volume.

Employment impacts on the wood processing industry were not assessed as the employment numbers in the wood to liquid fuel processing are not known.

Fuel Use

The amount of fuel consumed during the growing, harvesting and transport of the woody biomass was estimated;

Growing	0.13 l / m^3
Harvesting	3.40 to 3.70 l / m^3 (ground based or hauler logging)
Transport	1.7 l/m^3 for an 85 km haul (0.02 l / m^3 / km)
Total	5.23 to 5.53 l / m^3 at 85 km.

For variable distances;
Fuel use in litres per m^3
= 3.53 + (0.02*distance) ground based harvest, or
= 3.83 + (0.02*distance) hauler harvest,
where distance is in kilometres.

Note; from 1 m^3 of wood delivered, it is anticipated that 130 to 140 litres of ethanol or 95 to 100 litres of FT diesel could be produced. For an average transport distance of 85km the liquid fuel return on liquid fuel invested would be approximately 17 to 18 to 1.

Public versus Private Road use.

The GIS model used here does not differentiate between public and private roads, and should the capability be developed the analysis and interpretation would be complex and time consuming.

However, it is possible to give some general indications of the proportions of on- and off-highway transport. These differ between the two regions being assessed. It also differs with the total transport distance as some transport will be within a forest regardless of how far it is from the delivery point, and the greater the distance the forest is from the delivery point, the greater the proportion of the total distance will be on public roads.

Southland - Mataura

In Southland/Otago the forests are comparatively small and scattered (Figure 22), with a high percentage of the area owned by farm foresters, with the forests approaching their first harvest. This means that the only a small proportion of the total transport distance is likely to be on private roads. Further, this percentage will decrease as total distance increases. For example;

Landing to forest gate	7 km (14% private)
Forest gate to user site	43 km
Total	50km

Landing to forest gate	7 km (5% private)
Forest gate to user site	143 km
Total	150km

CNI - Kawerau

In the CNI the circumstances are different. Kawerau is located close to several large forests (Kaingaroa, Tarawera) which are onto their 2nd and 3rd rotations and so have well established and extensive off-highway roading infrastructure, much of specifically designed to get large volumes of wood to the Kawerau pulp mill (Figure 23). Therefore; for a large proportion of the wood that could be delivered (but not all of it) even at relatively large transport distances off-highway transport from and through Tarawera / Kaingaroa would be possible, and in may cases the cheapest option. For material coming through the forest rather than from it this assumes the owners would give access permission, which may incur a fee.

However, some of the material going to Kawerau would be more like the Southland case, with small in-forest distances and larger sectors on public roads (this would apply to material coming in from the east). As in Southland, the greater the transport distance, the greater the percentage would be travelled on public roads.

An estimate, based on the authors' knowledge, suggests that in Southland the proportion of transport on private roads would be in the order 5 to 10%. In the CNI case the proportion of off-highway transport would be much higher, and could exceed 50%.

Figure 22 – forests and roads in Otago and Southland

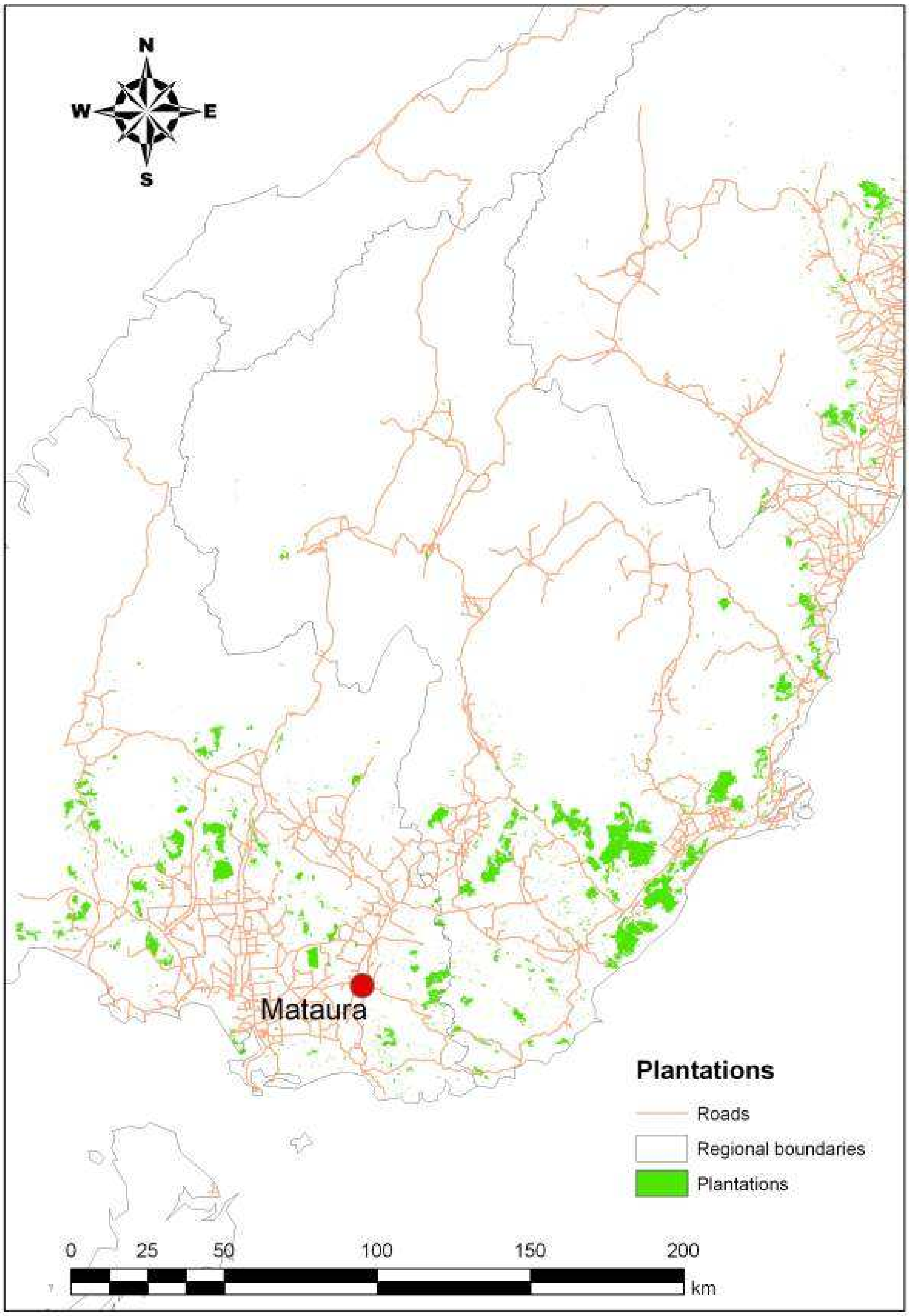
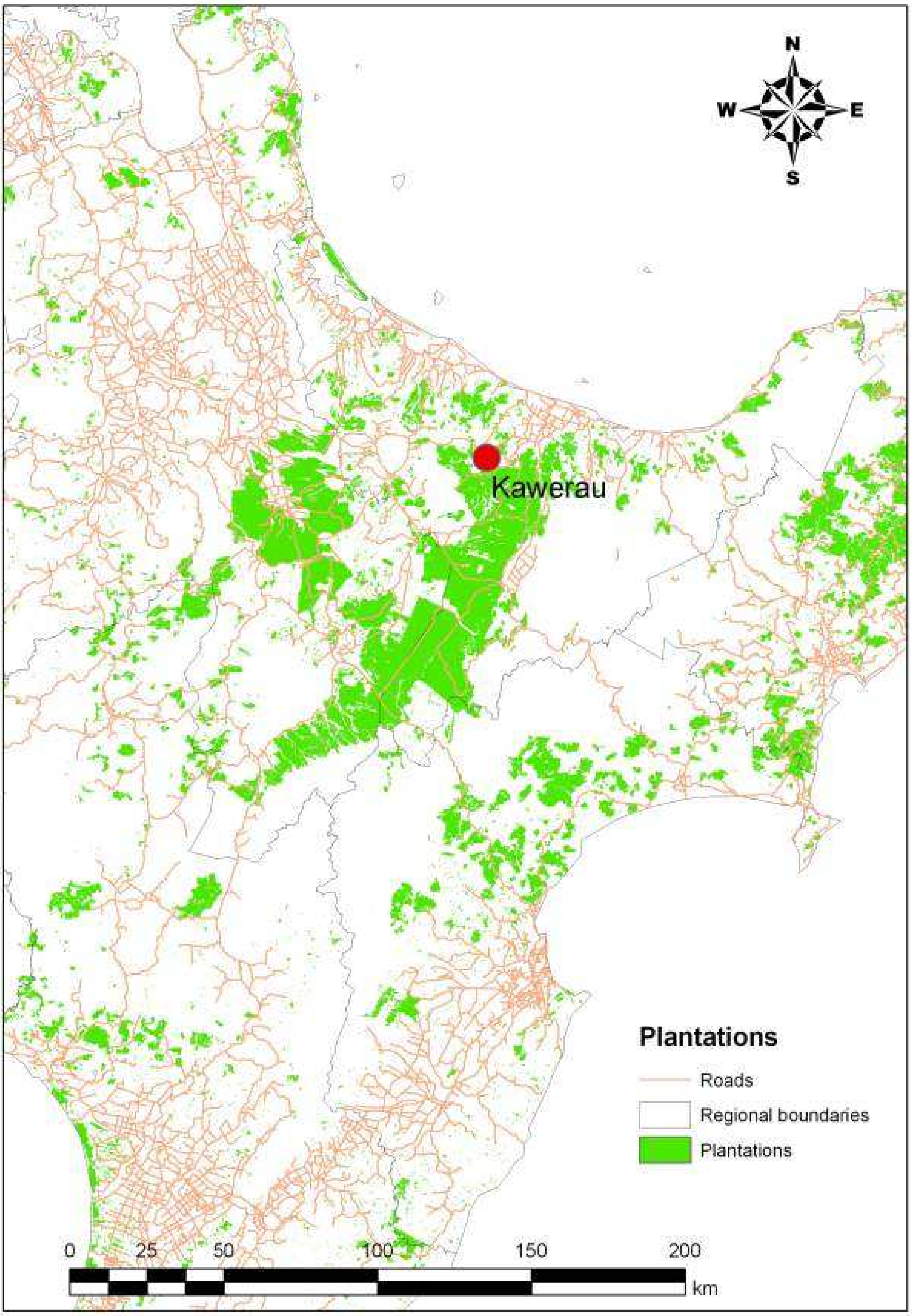


Figure 23 – forests and roads in the Central North Island



Maintaining peak supply volumes

If it was considered desirable to keep supply volumes at around the peak levels of 2025 to 2030, new plantings would be required.

In the case of the Southland site, the peak in forest harvest supply, at the highest price limit ($85/$m^3$) is 1.6 million m^3 per annum, which drops over the next 15 years to 0.5 million m^3 per annum. In order to maintain the peak of 1.6 million m^3 per annum new forest area would be required (assuming no change in the upper price limit). The amount of area required is approximately 40,000 ha of SRF or 56,000 ha of SRC, established at an even rate per annum so that the harvest can occur at an even rate. These areas are not large and there is easily sufficient land of suitable quality to allow this area to be established in Southland.

For the Kawerau site the case is somewhat different, as the volume peak in 2025 is very high (7.64 million m^3 per annum) and the drop off through to 2040 is large (5.35 million m^3 per annum). The areas required to make up all this shortfall would be in the order of 190,000 ha of new short rotation forest. Given that much of the area in the CNI is already afforested an increase of this size would be difficult to achieve. It is estimated that there could be around 30,000 ha of land suitable for new SRC or SRF forests in the catchments of Lakes Rotorua and Taupo. Further, it would be possible to establish another 30,000 ha of land that could be suitable for riparian margin planting in the Waikato region.

There are also large areas of land on the East Coast that would be suitable for afforestation, but all these options are at some distance from the Kawerau site and so delivery costs would be at the high end of the cost range. Given the scale of the drop of in supply in the CNI region (Figure 2) it would seem that only a partial mitigation of this supply drop-off would be possible, and that maintaining a supply of around 5.3 million tonnes per annum would be possible through increased afforestation of around 80,000 ha

CONCLUSIONS

Volumes available; the Kawerau site has much greater volumes of material available at the same prices and times, than Southland, due to the nature of the existing forest estate.

Table 8 – maximum volume by cost limit and year, Mataura, thousands of m^3 per annum

Cost limit	2015	2020	2025	2030	2035	2040
$40	24	20	54	43	26	16
$60	195	178	469	339	194	130
$85	764	736	1,902	1,415	746	541

Table 9 - maximum volume by cost limit and year, Kawerau, thousands of m^3 per annum

Cost limit	2015	2020	2025	2030	2035	2040
$40	164	168	249	255	171	83
$60	1,435	1,703	2,449	2,390	1,755	960
$85	4,721	5,653	8,971	7,866	5,968	3,314

All volumes are assumed to be potentially available, and material currently being utilised by existing industries is included in the data.

Current market prices for logs, adjusted for transport distance were assumed to be the best price indicator.

The supply of the wood has little impact on employment, with minor increases due to collection of residues and some drop in the amount of employment in transport due to the heavier trucks assumed to be used. The increases and drops in employment due to variations in recoverable log volumes were not assessed, as the man hours per unit of log harvest will not change and the variation in the volume of log harvest is driven by the availability of the wood, not its end-use.

The amount of log transport on private roads varies substantially by region, and reduces with increasing transport distance (volume of supply).

The greater the cost limit, the greater the transport distance that is possible, with $40, $60 and $85 cost limits having maximum transport distances of 80, 240 and 250 km respectively.

Volumes build to a peak in 2025 - 2030 and then drop away. This is due to the age class distribution of the existing estate. If a supply volume similar to the peak volumes reported was desired new plantings would be required, in order for this material to be available in time to be harvested in 2025 and 2030 it would have to be either a an SRF or SRC type crop. SRF is considered to be likely to be more cost effective.

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GLOSSARY AND CONVERSIONS

Glossary

CNI	central north island
GIS	geographic information system
GVM	gross vehicle mass (combination of tare and payload)
Tare	unladen weight
Payload	weight of a trucks load
m^3	cubic metre
odt	oven dry tonne
t	tonne
t km	tonne kilometre
$/t km	dollars per tonne kilometre
SRC	woody biomass grown via a system where the plant regrows from the cut stump after crop harvest
SRF	short rotation forestry (10 to 16 year rotations) woody crops, without coppicing

Conversions

1 m^3 of pinus radiata = 960 kg green
1 m^3 of pinus radiata = 430 kg od
1 green tonne of pinus radiata = 1.04 m^3
1 oven dry tone of pinus radiata = 2.32 m^3

APPENDICES

Appendix 1 – Item costs used in costing calculations where relevant (Informe Harvesting 2009).

Fuel					
Petrol	1.80	$/litre	1.74	Commercial small user r	
Diesel	1.15	$/litre	1.09	Commercial small user r	
Engine Oil	8.05	$/litre	7.00	Commercial small user r	
2 Stroke Oil	7.05	$/litre			
Chainsaw Bar Oil	3.61	$/litre			
Wages					
Adult Min	$12.50	$/hour		ACC	6.76 per $100
Operator	15.27 to 18.00	$/hour		Leave	20 days=7.69
Foreman	18.00 to 25.00	$/hour		Kiwisaver	2% of wages
Tyres					
Skidder	$4,600.00				
Loader	$6,700.00				
Forwarder	$4,100.00				
Ute / Van	$200 - $270				
Log Truck Tyres		Tyre company quote July 2009			
Steerer	$900.00	Discounted - full price $1250			
Driver	$430.00	Retread			
Trailer	$300.00				
Truck costs	**High**	**Low**			
Log Truck	$295,000.00	$255,000.00		Radios	$2,500.00
Log Trailer	$155,000.00	$140,000.00		Paint Job	$3,500.00
	$450,000.00	**$395,000.00**			
Chip truck	$340,000.00	$290,000.00			
Chip trailer	$175,000.00	$155,000.00			
	$515,000.00	**$445,000.00**			
Bin truck	$330,000.00	$310,000.00	$330,000		
Bin trailer	$155,000.00	$140,000.00	$100,000		
	$485,000.00	**$450,000.00**	**$430,000**		
Machine Prices					
19 - 22 tonne excavator		$337,000			
23 - 27 tonne excavator		$392,000			
28 - 32 tonne excavator		$440,000			
33 - 38 tonne excavator		$504,000			
Feller buncher 180 - 225 kW		$775,000			
Tracked skidder, 124 kW		$695,000			
Feller/processor, thinning		$577,000			
Feller/processor, clearfell		$848,000			
Forwarder 170 kW		$845,000			
Forwarder 140 kW		$750,000			
Tyred Loader 66 - 91 kW		$267,000			
Tyred Loader 92 - 130 kW		$304,000			
Tyred Loader 130 - 170 kW		$377,000			
Tyred Loader 171 - 230 kW		$509,000			
Skidder winch, 110 kW		$440,000	machine life 6580		
Skidder winch, <150 kW		$455,000	machine life 7230		
Skidder Grapple, 110 kW		$527,000	machine life 6580		
Skidder Grapple, <180 kW		$561,000	machine life 7230		
Hauler 60 ft		$985,000			
Hauler 80 ft		$1,290,000			
Hauler 85 ft		$1,353,000	Fully rigged		
Harvestline yarder		$510,000			
Swing Yarder, 335 kW		$1,800,000	Fully rigged		
Swingyarder, Large		500 to 600,000	Second hand EX Nth America		
Swingyarder, medium		400 to 500,000	Second hand EX Nth America		

Wire rope					m required		Total cost
	Sky	$19.90	$/m		600		$11,940.00
	Main	$17.90	$/m		700		$12,530.00
	Tail	$10.90	$/m		1400		$15,260.00
	Straw	$2.50	$/m		1500		$3,750.00
	Strops	$150.00	each		6		$900.00
	Chainsaws						
	Felling, 100cc+	2700	$				
	Skid, 70-95cc	2100	$				
	Chains	56	$				
	Bars	157	$				
	Tool kit	510	$				
Rigging							
	Butt Rigging	$4,800.00		1			
	Blocks	$1,500.00		2			
	Rider	$3,200.00		1			
	Shackles	$140.00		16			
	Signal system	$11,000.00		1			
	Radio	$5,000.00		1			
	Miscellaneous daily						
	Shelter	4.86	$/day				
	Tools	10.42	$/day				
	Consumables	29.54	$/day				
	Signs	9.52	$/day				
	Safety	3.1	$/day				
	Fire	5.72	$/day				
Utility Vehicle							
	4wd DC Ute	$51,500.00	Purchase			Radios	$2,500.00
	Tyres	$267.00	Each			Paint Job	$3,500.00
	RUCs	$32.92	1000/km				
	RnM	$2,259.00	pa				
	Depreciation	25	% pa		10 Year life		
	Rego	$321.00	pa				
	WoF	$85.00	pa				
	Insurance	$1,165.00	pa				
Crew Vehicle							
9 seat van		$60,000.00	Purchase				
	Tyres	$200.00	Each				
	RUCs	$32.95	1000/km				
	RnM	$2,622.00	pa				
	Depreciation	25	% pa				
	Rego	$321.00	pa				
	WoF	$85.00	pa				
	Insurance	$1,185.00	pa				

Appendix 2 – Examples from costing model

LABOUR COST ESTIMATE

1. Workdays per Year

Total Paid Days	260
+ Saturdays	5
	265
- Annual Holidays	20
- Statutory Holidays	10
- Wet Days	3
- Sick Leave	2
= Work Days:	230

3. Tax Free Allowances

Chainsaw Allowance per Day			42	
No.Men Receiving Allowance			9	
		Annual Total		86940
Protective Equipment Allowance Paid to Workers:				
	Number	Amount		
With Saws	9	754		
Without saw			Total	6786
Other Tax Free Allowances				
			TOTAL	93726

2. Gross Average Hourly Rate
(excluding tax free allowances)

Wage rates	Basic rate	Number	Total
1	25	1	25
2	$18.00	8	144
3	16	2	32
4			0
5			0
6			0
7			0
8			0
9			0
Contractor			0
		11	201
	Average Hourly Rate		18.27

4. Average annual cost of worker

	days/yr	hours/day	$ / hr	Total
Normal Time	245	11	18.27	49245
Travel Time	230	1	15	3450
Years Bonus				
Overtime	5	9	18	810
			Total	53505
+ Annual Holidays (as %)			7.70	57624.89
+ ACC Levy (as $ per $100)			6.75	61514.56
plus Kiwi saver (2%)				1152.498
Annual Cost of all Gang Members			=	677812.7
+ Tax Free Allowances(total 3.)			=	771538.7
Labour Cost per Workday			=	3354.516

Average Daily Cost per Man
304.96

CHAINSAW COSTING

Please Only Change Clear Cells!

Machine	Stihl 064		
Type	Petrol		
Capacity(cc)	85	Current New Price	2100
Year Purchased	2009	Hours per Year	1610
		Expected Life (years)	1
		Current Used Price	200
Costing Summary			
		Chain Bar Oil Price	3.61
Hours per Year	1610.00		
Hourly Fixed Costs	1.31	Average Capital Invested	2100
Hourly Running Costs	8.65	Fuel Tank Capacity (litres)	0.84
		Oil Tank Capacity (litres)	0.35
Chargeout Rate per Hour	**9.96**		
Chargeout Rate per Day	**69.75**	Fuel to Oil Ratio (.... to 1)	30
		Fuel Oil Price ($ per litre)	7.05
		Interest Rate	7
		Fuel Price ($ per litre)	1.69
		R + M as a % of depreciation *	100

Fixed Costs ($)		**Running Costs ($ / hr)**				
		Fuel Oil				0.43
		Fuel - Litres per Hour		1.89		3.19
Annual Depreciation	1900.00	Chain Oil -(l / hr)		0.665		2.40
		Repairs and Maintenance				1.18
		Chain	Price	56		
Hourly Rate	1.18		Life(days)	8	See below *	1.00
Average Capital Invested	2100	Bar	Price	157		0.45
Interest Rate	7		Life(days)	50	See below *	
Interest Charge per Hour	0.09					
Insurance (3% ACI)	0.04	Taxation				
Registration / Taxation	0					

* Chain life - For skid work on ash or sand - 2 to 3 days, other soil types - 4 to 6 days
Felling - clearfell - 15 days, thinning - 25 days
Thinnings skid work - 11 to 22 days, average 18.5 days
* Bar life - For skid work: clearfell 45 days, thinnings 120 days.
For felling: clearfell 80 days, thinnings 100 days.
R + M as a percentage of depreciation: felling 60 to 81cc - 60%, over 81cc - 50%
skids 60 to 81cc - 120%, over 81cc - 85%

Total Fuel	day	79.38
Total Fuel	year	18257.4
Fuel cost	year	$33,940.51

MACHINE COSTING 2

Return to workbook contents page to use 'save as' function

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Machine	Madill 171		
Type	Diesel		
Power (kw)	300	Current New Price	985000
Year Purchased	2009	Hours per Year	1610
		Hours to be Owned? 16000 gives life(yrs)	10
		Current Used Price	200000
Costing Summary		Tyre Life (hrs) *	1
		New Tyre Price	0
Hours per Year	1610.00		
Hourly Fixed Costs	97.61	Average Capital Invested	631750
Hourly Running Costs	98.01	Proportion of ACI as Loan	0.75
		Proportion of ACI as Owners Equity	0.25
Chargeout Rate per Hour	195.62		
		Loan Interest Rate	11
		Owners Interest Rate	6
		Fuel Price ($ per litre)	0.98
		R + M as a % of Depreciation	50

Fixed Costs ($)		**Running Costs ($ / hr)**	
		Fuel * 0.12 litres/kW/hr	35.28
Annual Depreciation	78500.00	Oil	5.29
		Repairs and Maintenance	24.38
		Tyres	0.00
Hourly Rate	48.76	Rigging	33.06
Average Capital Invested	631750		
Weighted Interest Rate	9.75		
Interest Charge per Hour	38.26		
Insurance	10.59	Taxation	

Fuel: machines average of 0.16 litres per kW per hour. haulers 0.11
Suggested hourly sum to transfer to savings for machine payments or replacement and R+M. $111.39

* Track R + M and replacement included in Repairs and maintenance.
* R & M as % of Depreciation, by operating conditions;
Easy 35% Medium 40% Hard 50%

Litres/year	57960
Litres/day	252
Fuel $/pa	56,801
Fuel $/day	246.96

ROPE AND RIGGING Cost per hour $33.06

Rope Type	Length (m)	Life (hrs)	Cost ($ / m)	Number	Cost ($/hr)
Mainrope	550	1500	17.9	1	$6.56
Skyline	500	3000	19.9	1	$3.32
Tailrope	950	2000	10.9	1	$5.18
Tagline	1000	5000	7	1	$1.40
Guyline	80	5000	18	5	$1.44
Extensions	200	5000	17.9	2	$1.43
Strawline	1500	5000	2.5	1	$0.75
Other	0	1	0	0	$0.00
Total					$20.08

Rigging Type	Life (hrs)	Cost	Number	Cost ($ / hr)
Butt rigging	5000	5000	1	1
Mainrope block	5000	3300	1	0.66
Fall block	5000	3800	1	0.76
Skyline block	5000	4400	1	0.88
Tailrope block	5000	700	3	0.42
Shotgun carriage	5000	4500	1	0.9
Slackpulling carriage	5000	12000	1	2.4
Shackles	5000	150	8	0.24
Talkie tooter system	9000	11000	1	1.22
Strops	200	150	6	4.5
Other	1			0
Other	1			0
Total				12.98

HARVESTING COSTS CALCULATOR Version 1.1
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Return to Intro

Only change clear cells!!

Workdays

Number of Workdays per Year: 230

Go to labour Worksheet for this calculation

Job Rate Summary

		Include in Job Cost Y' or 'N'	Hours per Workday (machines)	Cost per Workday
Labour table		Y		3354.52
Operating Supplies		y		199.07
Overheads		y		258.98
Chainsaws	Stihl 064	y	7	418.48
Number of saws at machine rate	6			
Vehicle 1	Hilux 3.0 4Wd	Y	150	125.83
		2 the same?	→	123.30
			km/day	
Vehicle 2	Isuzu NKR Van	y	150	156.42
		2 the same?	→	
			km/day	
Machine1	Bell Ultra	n	8	0.00
			hrs/day	
Machine2	Madill 171	y	7	1369.36
Machine3	Hitachi EX200-2	y	8	701.19
		2 the same?	→	701.19
Machine4	Cat 936 loader	n	9	0.00
		2 the same?	→	
Machine5	Cat 525 Cable skidder	n	7	0.00
		2 the same?	→	
Machine6	Cat 545 Grapple skidder	n	7	0.00
		2 the same?	→	1117.58
Machine7	Swing Yarder	n	7	0.00
Machine8	Fowarder	n	7	0.00
		2 the same?	→	
Machine9	Processor	n	6	0.00
		2 the same?	→	
Machine10	Feller Buncher	n	7	0.00
To Worksheet		2 the same?	→	
Machine11	2 stage off-highway truck	n	7	0.00
To Worksheet		2 the same?	→	
Total Cost of Operation per Workday				8525.92
Add Profit - a Percentage of Costs			6	9037.48
Divide by Production Estimate per Workday (tonnes)			258.7	
Gives Job Rate - $ / Tonne				34.93
			No. of machines	
Move in costs		y	4	0.33 $/t
Pick system from list			Hauler Prod	258.7
			$ per tonne	35.26

If the system is changed here, then the machines selected above need to change to a suitable crew structure selected by the user

Fuel Use

	Litres/day	Litres/tonne
Bell Ultra	0.0	0.000
Madill 171	252.0	0.974
Hitachi EX200-2	158.4	1.225
Cat 936 loader	0.0	0.000
Cat 525 Cable skidder	0.0	0.000
Cat 545 Grapple skidder	0.0	0.000
Swing Yarder	0.0	0.000
Fowarder	0.0	0.000
Processor	0.0	0.000
Feller Buncher	0.0	0.000
2 Stage off-highway truck	0.0	0.000
Total	410.4	2.2

Appendix 3 – Summarised Costs

Growing

- CNI $24.68/m^3 (yield of 704 m^3/ha)
- Southland $36.77/m^3 (yield of 520 m^3/ha)

See cost assumptions below (CNI example)

Growing costs: 28 year rotation

Change only clear cells

Interest rate 6%

Year		Per ha Operation	Land rent Per ha + Manage	Total	
1	Establish	$ 1,275	$100.00	$1,375.00	
2	Release	$230.00	$97.00	$327.00	$ 1,785
3	Release	$230.00	$97.00	$327.00	$ 2,219
4		$5.00	$95.00	$100.00	$ 2,452
5		$0.00	$95.00	$95.00	$ 2,694
6		$0.00	$93.00	$93.00	$ 2,948
7		$0.00	$93.00	$93.00	$ 3,218
8		$5.00	$93.00	$98.00	$ 3,509
9		$0.00	$93.00	$93.00	$ 3,813
10		$0.00	$93.00	$93.00	$ 4,135
11		$0.00	$93.00	$93.00	$ 4,476
12		$5.00	$93.00	$98.00	$ 4,842
13		$0.00	$93.00	$93.00	$ 5,226
14		$0.00	$93.00	$93.00	$ 5,632
15		$0.00	$93.00	$93.00	$ 6,063
16		$0.00	$93.00	$93.00	$ 6,520
17		$5.00	$93.00	$98.00	$ 7,009
18		$0.00	$95.00	$95.00	$ 7,525
19		$0.00	$95.00	$95.00	$ 8,072
20		$0.00	$95.00	$95.00	$ 8,651
21		$0.00	$95.00	$95.00	$ 9,265
22		$0.00	$95.00	$95.00	$ 9,916
23		$0.00	$95.00	$95.00	$ 10,606
24		$0.00	$95.00	$95.00	$ 11,337
25		$0.00	$140.00	$140.00	$ 12,157
26	Inventory	$10.00	$165.00	$175.00	$ 13,062
27	Road	$1,300.00	$165.00	$1,465.00	$ 15,310
28		$0.00	$165.00	$165.00	$ 16,394
					$ 17,378
				Vol/ha	704
				$ / m3	**$24.68**

6% **Profit**

Range likely ; Low 420 to Very high 910. Use P_Rad C

Or go to yeild tables

Go to Yeild Tables

Road build $/km	39,000	
ha of logging / km of road	30	
Roading $/ha	$1,300.00	
Roading $/m3	$1.85	

Land and establishment costs

Land capital	1500	$/ha
Land Rental	90	$/ha/pa
Prep spray	230	$/ha
Mech Prep	30	$/ha
Planting stock	400	$/ha
Planting Labour	380	$/ha
Release 1	230	$/ha
Misc	5	$/ha
Total	**1275**	**$/ha**

Transport

- 53 tonne GVM (36 tonne log payload)
- y = -0.0254Ln(x) + 0.3038, where y= $per tonne per kilometre and x = the transport distance in kilometres

Transport cost table

Distance, KM	$per t per km	$ per t
10	0.25	$2.45
20	0.23	$4.55
30	0.22	$6.52
40	0.21	$8.40
50	0.20	$10.22
60	0.20	$11.99
70	0.20	$13.71
80	0.19	$15.40
90	0.19	$17.06
100	0.19	$18.68
110	0.18	$20.28
120	0.18	$21.86
130	0.18	$23.42
140	0.18	$24.96
150	0.18	$26.48
160	0.17	$27.98
170	0.17	$29.47
180	0.17	$30.94
190	0.17	$32.40
200	0.17	$33.84

Truck and Trailer 120 km	Logs 120 km	
6X4 Truck & 4 Axle Trailer @ 53 Tonnes		

To start

Capital Costs

Truck Cost (excluding crane) Fully Rigged ($)	$345,000	
Trailer Cost Fully Rigged ($)	$175,000	
Self Loading Crane Cost	$0	
Interest Rate	11%	
Vehicle Life		Years
Truck & Crane (years)	700,000	4.19
Trailer (years)	500,000	5.98
Residual Values		
Truck & Crane (% of purchase price)	40%	$138,000
Trailer (% of purchase price)	33%	$57,750
Average Annual Investment (AAI)		$357,875

Unit Rates & Performance

Fuel Costs		
Diesel Cost ($/litre)	$1.05	
Oil Cost ($/litre)	$8.50	
Fuel Consumption		
Fuel (litre/100km)	55.00	59.125
Oil (litre/1000km)	1.50	1.6125
Crane Oil (use ltrs p.a.)	0	

Road User Charges	
Truck ($/1,000km)	$326.33
Trailer ($/1,000km)	$180.59
Annual registration	$400.00

Tyre Costs		
New 11r Truck Tyre Costs ($/tyre)	$800.00	
Truck Retread Costs ($/tyre)	$600.00	
New 255-70 Trailer Tyre Cost ($/tyre)	$650.00	
Trailer Retread Cost ($/tyre)	$450.00	
Tyre Life		
Front Axle: New (km/tyre)	50,000	46,250
Drive Tyre new (km/tyre)	80,000	74,000
Drive Tyre Retread	64,000	59,200
Trailer Tyre New	50,000	46,250
Trailer Tyre Retread	40,000	37,000
Number Of Front Axle Tyres	2	
Number of Drive tyres	8	
Number Tyres Trailer	16	
Percentage New Drive Tyres	10%	
Percentage New Trailer Tyres	10%	
Distance on Retread Compared To New Tyre	80%	

			Annual Costs
Maintenance			
Truck($/km)	$0.23	$0.25	$41,350
Trailer($/axle/100,000km)	$1,250.00	$1,343.75	$4,495
Turntables & Couplings ($/100,000 Trailer km)	$650.00	$698.75	$1,169
No of Trailer Axles	4		
No of Couplings & Turn Tables	2		
Scale Repairs ($ / 100,000 combined Km)	$650.00	$698.75	$1,753
Strutual Repairs ($ / 100,000 combined km)	$650.00	$698.75	$1,753
Crane Repairs ($ / 100,000 truck km)	$650.00	$698.75	$1,169
Painting (p.a)	$2,000.00		$2,150
Maint & Tyre Multiplier (for unsealed running)	1.50		
Insurance (2.35% of capital or own figure)	2.70%		$9,663

OPERATIONAL DETAILS

Average Trip Distance	240
Percentage Of Trip Vehicle Is Loaded	50%
Trips / Day	3.0
Productive Days (p.a)	226
Payload (tonnes)	36.0
Garage Distance Per Day	20
Percentage Trailer Is Piggy Backed	50%
Percentage Of Journey On Highway	80%
Percentage Of Journey On Seal	85%
Loads per trip	1

CALCULATIONS

Distances	
Truck Total	**167,240**
Truck On Highway	134,696
Truck Off Seal	24,408
Garaging	4,520
Trailer Total	**83,620**
Trailer On Highway	67,348
Trailer Off Seal	12,204
Trailer Garaging	2,260
PAYLOAD Per.Annum. (Tonnes)	24,408
PAYLOAD * DISTANCE Per.Annum. (Tonne-km)	2,928,960

Road User Charge (less GST)	
Truck RUC	$38,461
Trailer RUC	$10,642
Tyres	
Truck Tyres	$19,436
Trailer Tyres	$16,525
Maintenance	
Truck Maintenance (Incl Crane if Fitted)	$46,907
Trailer Maintenance	$6,931

COSTS Per.Annum. ($)		
Depreciation	$69,064	
Interest	$39,366	
Insurance	$9,663	**Fuel**
Registration	$400	**L/pa**
Fuel	$103,825	91,982
Oil	$2,292	**L/day**
Tyres	$35,961	407
Repairs & Maintenance	$53,838	**L/tonne**
Road User Charges	$49,103	3.769
Total Costs	$363,512	

Truck and Trailer 120 km	Logs 120 km	
6X4 Truck & 4 Axle Trailer @ 53 Tonnes		
	Fuel $ / day	427.35

Appendix 4 - Fuel use

Growing = 0.13 l/m^3

Logging
- Hauler = 3.7 l/m^3
- GB north = 3.1 l/m^3
- GB south = 3.4 l/m^3

Transport = 0.02 l per m^3 per km

Appendix 5 – Employment assumptions

Hauler crew = 5,400 m^3 per man per annum

Ground based North = 11,500 m^3 per man per annum

Ground based South = 10,350 m^3 per man per annum

Transport

Assuming a 70 km average lead; transport employment would be 1 man / truck per 32,000 tonnes delivered.

Landing residue harvest = 46,000 m^3 per man per annum
Landing residue transport = 30,000 m^3 per man per annum
Cutover residue harvest = 22,000 m^3 per man per annum
Cutover residue transport = 31,000 m^3 per man per annum

The residue harvest operations have much higher tonnages per man per annum than the traditional logging operations, as the labour inputs to the forest harvest contribute indirectly to the residue harvest.

Appendix 6 – Data tables;

Mataura; 2015 – wood volume (m^3 per annum) by cost and distance

Kilometres	$40 distance	$60 distance	$85 distance	$40 cumulative	$60 cumulative	$85 cumulative
5	2	10	14	2	10	14
10	40	296	415	42	306	429
15	132	978	1,374	174	1,284	1,804
20	602	4,465	6,272	776	5,749	8,076
25	695	4,688	6,683	1,472	10,437	14,759
30	1,794	12,536	17,769	3,266	22,973	32,528
35	491	3,569	5,027	3,756	26,542	37,555
40	2,641	16,656	24,011	6,397	43,198	61,566
45	3,083	15,174	28,464	9,481	58,372	90,030
50	2,548	6,024	24,583	12,029	64,396	114,614
55	1,388	3,107	13,097	13,417	67,503	127,710
60	3,038	5,354	26,210	16,455	72,858	153,920
65	2,390	5,320	22,497	18,845	78,177	176,417
70	3,126	6,932	29,384	21,971	85,110	205,801
75	2,748	5,002	23,977	24,719	90,112	229,777
80	264	4,816	23,206	24,984	94,928	252,984
85		4,932	14,705		99,861	267,688
90		5,952	19,633		105,812	287,322
95		7,984	24,363		113,796	311,685
100		7,749	22,647		121,545	334,332
105		10,350	32,167		131,895	366,499
110		6,879	22,665		138,774	389,165
115		6,965	29,469		145,739	418,634
120		4,877	30,421		150,616	449,055
125		6,232	42,332		156,848	491,387
130		5,889	40,070		162,737	531,457
135		3,335	23,831		166,072	555,287
140		3,287	23,226		169,358	578,513
145		1,732	11,172		171,090	589,685
150		1,859	11,340		172,949	601,026
155		926	5,799		173,875	606,825
160		3,457	19,437		177,332	626,262
165		4,461	23,458		181,792	649,720
170		4,911	24,321		186,703	674,041
175		290	1,711		186,993	675,752
180		545	3,385		187,538	679,137
185		1,347	7,745		188,885	686,882
190		584	3,589		189,469	690,471
195		923	4,750		190,392	695,221
200		184	36,860		190,576	732,081
205		184	1,298		190,760	733,380
210		159	1,168		190,920	734,548
215		165	1,133		191,084	735,681
220		434	2,910		191,518	738,591
225		504	3,617		192,022	742,208
230		1,817	10,890		193,840	753,097
235		990	6,446		194,830	759,543
240		601	3,375		195,430	762,918
245		313	856			763,774
250		-	645			764,418

Mataura; 2020 – wood volume (m^3 per annum) by cost and distance

Kilometres	$40 distance	$60 distance	$85 distance	$40 cumulative	$60 cumulative	$85 cumulative
5	35	262	368	35	262	368
10	241	1,791	2,516	277	2,053	2,883
15	148	1,092	1,534	425	3,145	4,418
20	899	6,520	9,190	1,324	9,665	13,607
25	444	3,192	4,504	1,768	12,857	18,111
30	1,370	10,138	14,243	3,138	22,995	32,354
35	800	5,588	7,921	3,938	28,582	40,274
40	1,217	8,301	11,811	5,155	36,884	52,086
45	1,662	6,324	15,343	6,817	43,207	67,429
50	3,074	7,505	30,063	9,891	50,713	97,491
55	1,076	2,428	10,184	10,967	53,140	107,676
60	2,991	6,100	27,211	13,959	59,241	134,886
65	1,094	2,619	10,612	15,053	61,860	145,499
70	2,907	6,337	27,137	17,960	68,197	172,636
75	2,430	4,300	20,994	20,390	72,497	193,629
80	181	4,811	21,878	20,571	77,308	215,507
85		8,088	23,613		85,396	239,120
90		4,368	14,439		89,764	253,559
95		10,235	32,202		99,999	285,761
100		8,352	25,678		108,351	311,438
105		16,568	47,073		124,919	358,512
110		7,713	21,992		132,632	380,504
115		6,018	24,483		138,650	404,986
120		3,363	22,225		142,012	427,211
125		6,456	45,094		148,468	472,305
130		5,169	30,544		153,637	502,849
135		2,333	15,171		155,969	518,020
140		2,511	17,526		158,480	535,546
145		3,188	20,766		161,669	556,312
150		1,500	9,611		163,168	565,923
155		1,719	10,862		164,888	576,785
160		3,562	20,629		168,450	597,414
165		955	5,270		169,405	602,684
170		433	2,283		169,838	604,967
175		322	1,777		170,160	606,744
180		265	1,581		170,425	608,325
185		167	1,062		170,592	609,387
190		249	1,591		170,841	610,977
195		1,135	5,563		171,976	616,540
200		118	40,851		172,094	657,391
205		118	40,851		172,213	698,241
210		135	795		172,348	699,036
215		910	4,832		173,257	703,869
220		90	669		173,348	704,537
225		500	3,193		173,848	707,730
230		1,946	11,605		175,794	719,335
235		1,598	9,965		177,392	729,300
240		502	3,160		177,893	732,460
245		574	3,063		178,467	735,523
250		265	681			736,204

Mataura; 2025 – wood volume (m^3 per annum) by cost and distance

Kilometres	\$40 distance	\$60 distance	\$85 distance	\$40 cumulative	\$60 cumulative	\$85 cumulative
5	76	563	790	76	563	790
10	512	3,796	5,331	588	4,358	6,121
15	347	2,567	3,606	934	6,925	9,727
20	2,075	15,046	21,203	3,009	21,971	30,930
25	1,142	8,279	11,668	4,151	30,250	42,598
30	4,200	31,059	43,640	8,351	61,309	86,238
35	2,143	14,871	21,102	10,494	76,180	107,340
40	3,210	21,732	30,959	13,704	97,911	138,299
45	4,351	16,003	40,383	18,055	113,915	178,681
50	8,452	20,754	82,853	26,506	134,669	261,534
55	2,836	6,516	27,042	29,343	141,185	288,577
60	7,491	14,862	67,442	36,834	156,047	356,018
65	2,676	6,318	25,800	39,510	162,365	381,819
70	7,487	15,904	69,183	46,996	178,269	451,002
75	6,930	12,132	59,646	53,926	190,401	510,648
80	531	13,782	62,723	54,457	204,183	573,371
85		22,767	66,520		226,950	639,891
90		12,242	39,860		239,192	679,751
95		30,431	95,782		269,623	775,534
100		22,490	68,737		292,113	844,271
105		43,801	125,232		335,915	969,503
110		21,056	60,048		356,970	1,029,550
115		16,051	65,198		373,021	1,094,749
120		8,327	54,919		381,348	1,149,668
125		15,725	109,959		397,073	1,259,627
130		12,319	72,652		409,393	1,332,278
135		4,811	30,621		414,204	1,362,899
140		3,471	24,403		417,675	1,387,303
145		8,867	57,142		426,542	1,444,445
150		2,857	18,560		429,399	1,463,005
155		4,015	25,452		433,413	1,488,457
160		7,130	42,237		440,543	1,530,694
165		1,308	7,251		441,851	1,537,945
170		592	3,169		442,443	1,541,114
175		495	2,830		442,938	1,543,945
180		351	2,119		443,289	1,546,064
185		305	2,046		443,594	1,548,110
190		338	2,187		443,932	1,550,297
195		1,521	7,487		445,453	1,557,784
200		168	117,496		445,620	1,675,280
205		168	117,496		445,788	1,792,776
210		205	1,157		445,993	1,793,934
215		1,290	7,065		447,282	1,800,999
220		307	2,278		447,589	1,803,277
225		1,471	9,732		449,060	1,813,009
230		5,969	35,440		455,030	1,848,449
235		4,863	30,278		459,893	1,878,727
240		1,525	9,544		461,418	1,888,271
245		1,899	10,524		463,317	1,898,795
250		1,270	3,221		464,587	1,902,016

Mataura; 2030 – wood volume (m^3 per annum) by cost and distance

Kilometres	$40 distance	$60 distance	$85 distance	$40 cumulative	$60 cumulative	$85 cumulative
5	-	-	-	-	-	-
10	122	903	1,269	122	903	1,269
15	32	238	335	154	1,142	1,604
20	884	6,492	9,132	1,038	7,634	10,736
25	1,363	9,938	13,993	2,401	17,572	24,729
30	4,036	29,470	41,487	6,437	47,041	66,215
35	2,059	13,139	18,903	8,497	60,180	85,119
40	2,937	19,569	27,951	11,434	79,749	113,070
45	3,327	19,091	32,745	14,761	98,841	145,815
50	3,434	7,576	32,210	18,195	106,417	178,025
55	540	941	4,639	18,734	107,358	182,663
60	4,942	8,848	42,871	23,677	116,206	225,534
65	7,110	13,824	63,533	30,787	130,030	289,067
70	5,430	9,464	46,664	36,217	139,494	335,731
75	6,298	10,488	53,294	42,515	149,982	389,025
80	1,187	13,958	57,191	43,702	163,941	446,216
85		10,259	41,517		174,200	487,733
90		9,718	33,413		183,918	521,146
95		18,913	63,880		202,831	585,026
100		34,940	101,847		237,771	686,873
105		25,052	78,658		262,823	765,531
110		4,833	14,825		267,657	780,356
115		2,162	9,591		269,819	789,947
120		5,548	34,940		275,367	824,887
125		12,011	73,940		287,379	898,827
130		12,829	74,282		300,207	973,109
135		9,003	53,934		309,210	1,027,043
140		2,315	14,672		311,525	1,041,715
145		1,318	7,937		312,843	1,049,653
150		1,382	7,829		314,225	1,057,482
155		1,891	11,835		316,116	1,069,317
160		2,274	13,176		318,390	1,082,493
165		1,513	9,007		319,903	1,091,501
170		162	813		320,065	1,092,314
175		416	2,057		320,481	1,094,371
180		396	2,358		320,878	1,096,729
185		369	2,288		321,246	1,099,017
190		983	6,211		322,229	1,105,228
195		595	3,116		322,824	1,108,344
200		237	104,887		323,061	1,213,230
205		288	104,887		323,350	1,318,117
210		291	2,056		323,641	1,320,173
215		224	1,224		323,865	1,321,397
220		502	3,086		324,366	1,324,483
225		757	4,800		325,123	1,329,283
230		5,279	29,916		330,403	1,359,199
235		2,173	11,559		332,576	1,370,758
240		1,374	7,844		333,950	1,378,602
245		5,391	36,300		339,341	1,414,902
250		340	882			1,415,783

Mataura; 2035 – wood volume (m^3 per annum) by cost and distance

Kilometres	$40 distance	$60 distance	$85 distance	$40 cumulative	$60 cumulative	$85 cumulative
5	2	11	15	2	11	15
10	37	273	384	39	284	399
15	131	971	1,364	170	1,255	1,763
20	568	4,216	5,921	738	5,471	7,684
25	575	3,902	5,557	1,313	9,373	13,240
30	1,716	11,921	16,913	3,029	21,294	30,153
35	464	3,385	4,766	3,493	24,680	34,919
40	2,550	16,089	23,193	6,043	40,769	58,112
45	2,890	14,195	26,834	8,933	54,964	84,946
50	2,703	6,493	26,253	11,637	61,457	111,199
55	1,557	3,465	14,654	13,193	64,922	125,853
60	3,896	6,915	33,692	17,089	71,836	159,545
65	3,038	6,452	28,073	20,128	78,288	187,618
70	3,317	7,203	30,918	23,445	85,491	218,536
75	3,008	5,305	25,955	26,453	90,797	244,491
80	352	5,604	26,625	26,804	96,400	271,116
85		5,251	16,016		101,651	287,132
90		6,377	20,765		108,028	307,897
95		8,991	27,033		117,020	334,930
100		9,908	28,428		126,927	363,358
105		13,159	40,576		140,087	403,934
110		8,081	26,498		148,168	430,432
115		8,743	37,742		156,911	468,174
120		7,132	44,358		164,042	512,532
125		9,123	61,921		173,165	574,453
130		6,780	45,419		179,945	619,871
135		2,249	15,908		182,195	635,779
140		1,470	10,403		183,664	646,183
145		1,296	8,106		184,961	654,289
150		852	5,224		185,813	659,513
155		505	3,124		186,318	662,637
160		1,129	6,549		187,448	669,186
165		1,180	6,260		188,628	675,447
170		1,313	6,536		189,941	681,982
175		92	555		190,032	682,537
180		237	1,555		190,269	684,093
185		369	2,124		190,638	686,216
190		166	1,037		190,804	687,253
195		239	1,254		191,043	688,507
200		66	20,194		191,108	708,701
205		66	20,194		191,174	728,895
210		67	487		191,241	729,381
215		66	481		191,307	729,862
220		85	582		191,392	730,444
225		238	1,603		191,631	732,047
230		285	2,052		191,916	734,099
235		1,000	5,948		192,916	740,046
240		511	3,347		193,427	743,393
245		353	2,011		193,780	745,404
250		242	660		194,022	746,065

Mataura; 2040 – wood volume (m^3 per annum) by cost and distance

Kilometres	$40 distance	$60 distance	$85 distance	$40 cumulative	$60 cumulative	$85 cumulative
5	14	65	91	14	65	91
10	122	908	1,275	136	972	1,365
15	99	733	1,030	235	1,705	2,396
20	394	2,910	4,089	629	4,616	6,485
25	616	4,017	5,757	1,245	8,632	12,242
30	911	6,346	8,999	2,155	14,978	21,241
35	336	2,467	3,471	2,492	17,446	24,712
40	1,254	8,004	11,514	3,745	25,450	36,226
45	1,454	7,087	13,588	5,199	32,536	49,814
50	1,494	3,634	14,585	6,693	36,170	64,399
55	929	2,052	8,719	7,622	38,222	73,118
60	2,429	4,372	21,112	10,051	42,595	94,231
65	2,253	4,967	21,127	12,305	47,561	115,358
70	2,012	4,318	18,665	14,316	51,879	134,022
75	1,667	2,869	14,264	15,983	54,748	148,287
80	218	3,233	15,358	16,201	57,981	163,645
85		2,841	8,696	16,201	60,822	172,341
90		3,452	11,132		64,274	183,473
95		4,907	14,555		69,181	198,028
100		6,106	17,541		75,288	215,569
105		8,279	25,307		83,567	240,876
110		4,804	15,645		88,371	256,520
115		5,592	24,164		93,962	280,684
120		4,705	29,240		98,667	309,924
125		5,943	40,333		104,611	350,258
130		4,485	30,150		109,095	380,407
135		2,011	14,279		111,106	394,687
140		2,058	14,477		113,165	409,164
145		835	5,480		114,000	414,644
150		1,202	7,364		115,202	422,009
155		542	3,427		115,744	425,436
160		2,453	13,663		118,198	439,098
165		3,204	16,767		121,402	455,866
170		3,545	17,529		124,946	473,395
175		244	1,458		125,191	474,852
180		392	2,428		125,583	477,281
185		993	5,631		126,576	482,912
190		424	2,595		127,001	485,506
195		874	4,461		127,875	489,968
200		160	18,087		128,034	508,055
205		160	18,087		128,194	526,142
210		163	1,093		128,357	527,235
215		107	786		128,464	528,021
220		99	648		128,563	528,669
225		198	1,326		128,761	529,995
230		263	1,885		129,023	531,880
235		771	4,634		129,794	536,514
240		396	2,619		130,190	539,133
245		362	2,119			541,251
250		253	646			

Kawerau; 2015 - wood volume (m^3 per annum) by cost and distance

Kilometres	$40 distance	$60 distance	$85 distance	$40 cumulative	$60 cumulative	$85 cumulative
5	355	1,060	1,488	355	1,060	1,488
10	2,173	15,822	22,283	2,528	16,881	23,771
15	6,892	48,109	68,201	9,420	64,991	91,972
20	10,113	67,774	96,711	19,533	132,764	188,683
25	9,331	59,771	85,936	28,864	192,535	274,619
30	13,811	90,944	130,151	42,674	283,479	404,770
35	16,834	109,966	157,584	59,508	393,445	562,354
40	18,908	125,277	179,103	78,416	518,723	741,456
45	9,558	56,694	91,451	87,974	575,416	832,908
50	5,540	13,440	54,030	93,514	588,856	886,937
55	9,741	22,426	92,954	103,255	611,282	979,892
60	12,643	27,339	117,652	115,899	638,621	1,097,544
65	13,563	30,660	128,471	129,462	669,281	1,226,015
70	16,169	35,061	150,627	145,631	704,342	1,376,641
75	17,166	35,852	157,588	162,797	740,194	1,534,230
80	1,879	27,309	105,390	164,676	767,504	1,639,619
85		43,905	119,565		811,408	1,759,184
90		47,577	135,783		858,985	1,894,967
95		50,204	147,855		909,189	2,042,822
100		52,331	157,421		961,520	2,200,243
105		51,015	150,292		1,012,534	2,350,534
110		48,214	141,120		1,060,749	2,491,655
115		35,077	141,095		1,095,825	2,632,749
120		16,105	101,554		1,111,930	2,734,303
125		15,590	98,463		1,127,521	2,832,766
130		12,216	75,320		1,139,737	2,908,086
135		8,503	58,310		1,148,240	2,966,397
140		7,363	50,669		1,155,604	3,017,065
145		7,088	46,626		1,162,692	3,063,692
150		13,750	83,364		1,176,441	3,147,056
155		13,053	79,586		1,189,494	3,226,642
160		10,120	60,809		1,199,614	3,287,451
165		7,137	46,176		1,206,751	3,333,626
170		5,746	33,978		1,212,497	3,367,604
175		6,684	39,473		1,219,181	3,407,077
180		13,247	80,650		1,232,427	3,487,727
185		14,482	83,921		1,246,909	3,571,648
190		19,123	110,750		1,266,033	3,682,399
195		18,779	111,134		1,284,812	3,793,533
200		21,474	118,299		1,306,285	3,911,832
205		9,706	54,373		1,315,991	3,966,205
210		17,427	95,293		1,333,418	4,061,498
215		13,596	74,267		1,347,014	4,135,765
220		20,482	116,213		1,367,496	4,251,978
225		19,033	105,847		1,386,530	4,357,825
230		24,686	130,549		1,411,216	4,488,374
235		25,999	119,493		1,437,214	4,607,866
240		15,840	30,577		1,453,055	4,638,443
245		-	34,203		1,453,055	4,672,646
250		-	48,481			4,721,126

Kawerau; 2020 - wood volume (m^3 per annum) by cost and distance

Kilometres	$40 distance	$60 distance	$85 distance	$40 cumulative	$60 cumulative	$85 cumulative
5	960	6,039	8,710	1,025	6,492	9,352
10	7,906	53,286	75,968	8,931	59,779	85,320
15	8,415	57,504	81,798	17,347	117,283	167,118
20	13,677	96,510	136,584	31,024	213,792	303,702
25	9,264	62,430	89,006	40,289	276,222	392,708
30	9,461	62,892	89,866	49,750	339,115	482,573
35	11,424	80,683	114,169	61,174	419,798	596,743
40	10,463	60,107	102,204	71,637	479,904	698,947
45	8,984	22,365	88,583	80,620	502,269	787,530
50	14,913	37,196	147,166	95,533	539,465	934,696
55	17,661	45,954	177,517	113,194	585,419	1,112,213
60	20,452	51,189	202,131	133,646	636,608	1,314,343
65	16,834	42,997	167,837	150,479	679,605	1,482,180
70	14,117	35,063	139,065	164,596	714,668	1,621,245
75	3,631	33,636	125,759	168,228	748,304	1,747,004
80		51,555	141,028		799,858	1,888,032
85		67,811	188,447		867,669	2,076,478
90		87,266	232,474		954,936	2,308,953
95		109,860	301,974		1,064,795	2,610,927
100		123,577	352,707		1,188,372	2,963,633
105		86,773	249,114		1,275,145	3,212,748
110		33,670	146,743		1,308,815	3,359,491
115		18,548	131,290		1,327,363	3,490,780
120		22,643	157,278		1,350,006	3,648,058
125		11,805	84,915		1,361,811	3,732,973
130		6,182	44,355		1,367,993	3,777,328
135		9,180	59,970		1,377,172	3,837,298
140		5,533	39,268		1,382,706	3,876,566
145		4,017	28,091		1,386,723	3,904,657
150		6,584	47,191		1,393,307	3,951,848
155		7,748	52,047		1,401,055	4,003,896
160		6,224	39,840		1,407,279	4,043,736
165		6,820	40,768		1,414,099	4,084,504
170		8,896	49,494		1,422,995	4,133,998
175		11,160	66,316		1,434,155	4,200,314
180		15,064	89,191		1,449,219	4,289,505
185		11,452	67,692		1,460,671	4,357,197
190		12,851	69,481		1,473,521	4,426,678
195		29,722	159,822		1,503,243	4,586,501
200		28,316	153,511		1,531,559	4,740,011
205		35,805	197,928		1,567,365	4,937,939
210		10,932	61,224		1,578,297	4,999,163
215		22,307	121,778		1,600,604	5,120,941
220		18,736	111,729		1,619,340	5,232,670
225		26,578	140,370		1,645,918	5,373,039
230		42,165	202,755		1,688,083	5,575,794
235		15,015	31,023		1,703,097	5,606,817
240		-	22,707			5,629,524
245		-	24,312			5,653,836
250			24,312			4,831,739

Kawerau; 2025 - wood volume (m^3 per annum) by cost and distance

Kilometres	$40 distance	$60 distance	$85 distance	$40 cumulative	$60 cumulative	$85 cumulative
5	89	615	872	89	615	872
10	1,549	9,785	14,102	1,637	10,400	14,974
15	12,969	87,616	124,861	14,606	98,016	139,835
20	14,090	96,302	136,981	28,696	194,317	276,817
25	19,485	137,947	195,127	48,181	332,265	471,943
30	13,977	94,014	134,075	62,159	426,279	606,019
35	14,552	98,177	139,943	76,711	524,456	745,961
40	17,351	121,883	172,615	94,061	646,339	918,576
45	17,017	97,358	165,398	111,079	743,697	1,083,974
50	14,427	35,793	142,051	125,506	779,491	1,226,025
55	21,733	53,726	213,655	147,239	833,217	1,439,681
60	24,443	64,050	246,447	171,681	897,267	1,686,127
65	27,957	72,021	279,779	199,638	969,287	1,965,906
70	25,412	66,173	255,512	225,050	1,035,460	2,221,418
75	19,665	50,815	197,060	244,715	1,086,275	2,418,478
80	5,269	45,576	171,639	249,984	1,131,852	2,590,117
85	-	52,204	142,345		1,184,055	2,732,463
90		67,262	183,916		1,251,317	2,916,379
95		77,929	206,225		1,329,246	3,122,604
100		58,798	160,264		1,388,044	3,282,868
105		64,450	181,407		1,452,494	3,464,275
110		44,313	124,278		1,496,807	3,588,552
115		14,765	72,094		1,511,572	3,660,646
120		7,750	56,733		1,519,323	3,717,379
125		11,093	77,280		1,530,416	3,794,659
130		3,965	27,749		1,534,381	3,822,408
135		5,947	42,582		1,540,328	3,864,990
140		12,574	80,573		1,552,902	3,945,563
145		6,379	44,756		1,559,281	3,990,320
150		5,024	34,402		1,564,306	4,024,722
155		13,109	94,516		1,577,415	4,119,237
160		12,954	83,605		1,590,369	4,202,843
165		10,850	65,342		1,601,219	4,268,185
170		15,358	89,000		1,616,577	4,357,185
175		21,616	120,971		1,638,193	4,478,155
180		33,047	192,343		1,671,240	4,670,498
185		36,740	215,086		1,707,981	4,885,584
190		25,292	148,621		1,733,273	5,034,205
195		35,734	191,492		1,769,007	5,225,697
200		87,061	472,415		1,856,068	5,698,112
205		87,537	475,393		1,943,604	6,173,506
210		94,433	524,834		2,038,037	6,698,339
215		49,308	268,122		2,087,345	6,966,461
220		65,992	373,823		2,153,336	7,340,284
225		65,449	395,544		2,218,785	7,735,828
230		81,147	437,371		2,299,932	8,173,199
235		104,430	502,873		2,404,363	8,676,072
240		45,446	88,198		2,449,809	8,764,270
245		-	68,969			8,833,239
250		-	138,758			8,971,997

Kawerau; 2030 - wood volume (m^3 per annum) by cost and distance

Kilometres	$40 distance	$60 distance	$85 distance	$40 cumulative	$60 cumulative	$85 cumulative
5	426	2,809	3,964	426	2,809	3,964
10	6,953	43,576	62,888	7,380	46,385	66,852
15	7,192	45,871	66,000	14,572	92,256	132,852
20	16,734	109,850	157,288	31,305	202,106	290,140
25	28,002	183,339	262,628	59,307	385,445	552,768
30	22,733	155,946	221,690	82,040	541,392	774,459
35	21,666	151,806	215,080	103,706	693,198	989,538
40	19,588	133,002	189,386	123,294	826,200	1,178,925
45	12,518	76,290	119,289	135,812	902,490	1,298,213
50	7,647	17,859	73,402	143,458	920,349	1,371,616
55	15,189	40,620	154,535	158,648	960,969	1,526,151
60	25,172	65,967	253,809	183,819	1,026,936	1,779,960
65	30,186	71,045	290,690	214,006	1,097,981	2,070,649
70	19,477	47,196	189,861	233,483	1,145,177	2,260,510
75	20,537	50,527	201,487	254,020	1,195,704	2,461,997
80	1,487	24,844	89,028	255,507	1,220,547	2,551,025
85	-	55,635	162,139		1,276,182	2,713,164
90		90,860	257,018		1,367,042	2,970,182
95		60,122	164,195		1,427,164	3,134,377
100		114,092	333,670		1,541,256	3,468,047
105		123,402	380,272		1,664,658	3,848,320
110		89,481	286,796		1,754,139	4,135,116
115		33,164	150,830		1,787,303	4,285,946
120		18,657	128,928		1,805,960	4,414,875
125		17,609	126,209		1,823,569	4,541,084
130		25,803	184,321		1,849,372	4,725,405
135		7,897	54,180		1,857,269	4,779,585
140		13,453	92,744		1,870,722	4,872,329
145		11,924	79,666		1,882,645	4,951,995
150		3,174	22,489		1,885,820	4,974,484
155		14,007	91,547		1,899,827	5,066,032
160		22,809	144,653		1,922,635	5,210,684
165		20,537	132,720		1,943,172	5,343,404
170		13,174	86,512		1,956,346	5,429,916
175		12,431	80,344		1,968,777	5,510,260
180		12,722	76,850		1,981,499	5,587,110
185		11,739	72,749		1,993,238	5,659,859
190		15,377	88,528		2,008,615	5,748,387
195		20,562	119,095		2,029,177	5,867,482
200		26,848	149,106		2,056,024	6,016,588
205		34,608	187,977		2,090,633	6,204,564
210		40,952	237,679		2,131,585	6,442,243
215		21,759	126,931		2,153,343	6,569,175
220		28,434	155,442		2,181,778	6,724,617
225		56,188	309,336		2,237,965	7,033,953
230		69,830	381,200		2,307,795	7,415,153
235		62,779	317,460		2,370,574	7,732,613
240		20,178	42,602		2,390,752	7,775,215
245		-	35,955			7,811,170
250		-	55,656			7,866,826

Kawerau; 2035 - wood volume (m^3 per annum) by cost and distance

Kilometres	$40 distance	$60 distance	$80 distance	$40 cumulative	$60 cumulative	$80 cumulative
5	312	983	1,382	312	983	1,382
10	1,828	13,339	18,780	2,140	14,322	20,162
15	6,137	42,761	60,636	8,277	57,083	80,798
20	10,031	67,284	95,999	18,308	124,367	176,797
25	8,869	56,778	81,641	27,176	181,145	258,438
30	14,316	92,996	133,390	41,492	274,141	391,828
35	18,226	120,018	171,759	59,719	394,159	563,586
40	20,859	138,789	198,282	80,578	532,948	761,868
45	9,747	58,162	94,019	90,325	591,109	855,887
50	7,391	18,781	73,523	97,715	609,890	929,411
55	12,716	30,924	124,143	110,431	640,814	1,053,554
60	15,417	35,938	147,875	125,848	676,752	1,201,429
65	16,537	38,617	158,737	142,386	715,369	1,360,166
70	12,740	31,300	124,916	155,126	746,669	1,485,081
75	15,299	37,231	149,403	170,424	783,900	1,634,485
80	1,438	27,523	103,437	171,863	811,423	1,737,922
85	-	52,911	143,742		864,334	1,881,664
90		65,989	183,523		930,323	2,065,186
95		70,175	196,096		1,000,498	2,261,282
100		87,675	250,204		1,088,173	2,511,486
105		77,714	223,153		1,165,887	2,734,639
110		66,237	186,342		1,232,124	2,920,981
115		49,007	199,241		1,281,131	3,120,222
120		26,006	174,299		1,307,137	3,294,522
125		24,654	174,017		1,331,792	3,468,539
130		13,715	96,491		1,345,507	3,565,030
135		11,177	75,022		1,356,684	3,640,052
140		28,597	159,494		1,385,281	3,799,546
145		20,621	126,221		1,405,902	3,925,767
150		55,045	314,667		1,460,947	4,240,434
155		14,418	93,882		1,475,365	4,334,316
160		22,605	143,803		1,497,970	4,478,120
165		14,400	95,909		1,512,370	4,574,029
170		6,292	37,185		1,518,661	4,611,213
175		8,282	49,915		1,526,943	4,661,128
180		15,035	94,412		1,541,978	4,755,540
185		12,948	76,578		1,554,925	4,832,118
190		18,934	110,095		1,573,859	4,942,213
195		21,624	128,525		1,595,483	5,070,738
200		26,313	145,078		1,621,796	5,215,816
205		12,375	69,820		1,634,171	5,285,635
210		20,843	115,992		1,655,014	5,401,627
215		15,653	89,113		1,670,668	5,490,740
220		20,155	118,304		1,690,822	5,609,044
225		15,080	85,053		1,705,902	5,694,098
230		18,130	98,366		1,724,032	5,792,463
235		17,128	83,433		1,741,160	5,875,896
240		14,242	26,183		1,755,402	5,902,079
245		-	36,240			5,938,319
250		-	30,062			5,968,381

<u>Kawerau;</u> 2040 - wood volume (m^3 per annum) by cost and distance

Kilometres	$40 distance	$60 distance	$85 distance	$40 cumulative	$60 cumulative	$85 cumulative
5	192	615	864	192	615	864
10	1,147	8,377	11,793	1,339	8,993	12,657
15	3,808	26,514	37,603	5,147	35,506	50,260
20	5,500	36,909	52,656	10,647	72,415	102,916
25	5,108	32,747	47,075	15,755	105,162	149,991
30	7,312	48,220	68,990	23,067	153,381	218,982
35	8,898	58,074	83,233	31,965	211,455	302,215
40	9,757	64,689	92,473	41,722	276,145	394,688
45	4,794	28,361	45,752	46,516	304,505	440,440
50	2,698	6,450	26,150	49,213	310,956	466,590
55	5,081	11,473	48,103	54,294	322,428	514,693
60	6,105	13,200	56,806	60,398	335,629	571,499
65	6,642	15,090	63,039	67,040	350,719	634,539
70	7,392	17,076	70,641	74,432	367,795	705,179
75	7,929	17,609	74,569	82,361	385,404	779,748
80	1,016	18,367	67,952	83,377	403,771	847,700
85	-	37,793	101,127		441,564	948,827
90		38,996	106,932		480,559	1,055,759
95		40,881	113,131		521,441	1,168,890
100		44,094	124,449		565,535	1,293,339
105		48,119	136,441		613,654	1,429,780
110		45,213	127,949		658,867	1,557,729
115		29,810	116,630		688,677	1,674,360
120		11,604	79,635		700,282	1,753,995
125		12,111	82,255		712,393	1,836,250
130		8,475	57,134		720,868	1,893,383
135		8,680	59,534		729,548	1,952,917
140		7,183	49,618		736,731	2,002,534
145		6,813	45,363		743,544	2,047,897
150		9,992	65,177		753,536	2,113,075
155		8,995	58,641		762,531	2,171,716
160		7,203	44,391		769,734	2,216,107
165		5,686	37,258		775,420	2,253,365
170		5,336	32,120		780,756	2,285,485
175		4,765	29,470		785,521	2,314,955
180		10,154	65,303		795,675	2,380,258
185		10,090	59,878		805,765	2,440,136
190		14,397	85,862		820,162	2,525,997
195		14,930	89,973		835,092	2,615,971
200		17,474	97,197		852,566	2,713,168
205		7,330	40,900		859,896	2,754,069
210		13,118	71,369		873,015	2,825,437
215		10,322	55,500		883,337	2,880,938
220		14,463	81,598		897,800	2,962,536
225		14,452	81,654		912,252	3,044,190
230		18,046	97,025		930,298	3,141,215
235		19,249	89,261		949,547	3,230,476
240		11,452	22,371		960,999	3,252,847
245		-	26,776			3,279,622
250		-	34,662			3,314,284