What proportion of the forest of small-scale owners is likely to be harvested – a Whanganui case study

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Abstract

National and regional wood supply forecasts indicate that small-scale forests will provide an increasing proportion of New Zealand's harvest volumes over the next decade. However these forecasts are based on physical factors only and do not consider harvest costs. Because of size, location and terrain, some small-scale forests may not be economic to harvest.

In a case study, carried out in Whanganui District, the delivered wood cost including harvesting, roading and transportation, was estimated for a sample of 58 small-scale forest blocks. Taken into account were the size, slope, location and roading requirements of each block. Initial analysis, assuming harvesting at age 30 years, found a distribution of costs, with the majority of blocks in the range $53 a tonne to $87 a tonne, with an average of $70 a tonne. However there were five blocks with delivered wood cost exceeding $100 a tonne.

The optimum rotation age for these five blocks was found to be at least 49 years at which age costs are $89 a tonne to $107 a tonne. Given that average market prices for logs over the last five years in the region have been $84 a tonne, it is probable that these blocks will only be harvested at old ages and at times of exceptionally high average log prices.

This study is based on generic assumptions about silviculture, yields and market destinations. However it indicates that five to 10 per cent of the area of small-scale blocks in the Whanganui District may never be harvested.

Introduction

In 2010 MAF completed wood availability forecasts for all regions in New Zealand (MAF 2010). The forecasts are supply-based and show the range of harvest volumes which are potentially available for the plantation estate given the planted area and expected volumes. They are not based on economic factors – neither future market conditions nor the cost of production is explicitly included.

Separate forecasts were produced for the estates of large-scale owners owning over 1,000 hectares and small-scale owners. The forecasts indicate that 'Between 2009 and 2015, the small-scale owners' forests have the capacity to provide an additional three to four million cubic metres a year. After 2015, and leading into the 2020s, the potential wood available from the small-scale owners' forests increases up to 15 million cubic metres per annum. (MAF, 2010).

The small-scale resource is poorly understood and comprises a large number of owners, some of whom may have established forests without much consideration of the cost and practicality of harvesting. As noted in MAF (2010), 'Some forests may not be harvested. For instance forests on steep terrain, distant from processing plants/ports, small in size or without existing roads may be uneconomic to harvest if logging and transport costs are higher than the market value of the forests' recoverable log volume.'

A further unknown is the extent to which the Emissions Trading Scheme (ETS) could affect future harvesting decisions. Maclaren and Manley (2008) found that the ETS favours longer rotations. Forest owners who enter their forests in the ETS may decide to lengthen the age that they harvest their forests, or with sufficiently high prices for emission units could decide not to harvest.

The basis of the study reported here was undertaken as part of an MForSc thesis. The purpose of the study is to provide an improved understanding of the proportion of the small-scale resource likely to be harvested. The small-scale owners' estate in Whanganui district is used as a case study to estimate the proportion of the small-scale resource which would be harvested at different log price levels.

Initially the total delivered wood cost is estimated for a sample of forest blocks assuming a rotation age of 30 years. Then total cost is estimated for the financial optimum rotation age for each block. The distribution of costs is compared with recent log prices to indicate the proportion of stands that will generate a negative stumpage and are therefore unlikely to be harvested. Finally, the optimum rotation age is estimated with the inclusion of carbon trading under the ETS.

Methods

Forest area

Whanganui District was chosen because it has a substantial area of small-scale forest and a good spatial description on the resource was available. ArcGIS shape files which had been produced for a study on forestry road use were also available. The data consisted of boundary, area and location information on 1,034 exotic forest blocks as well as other information on species, ownership, and planting years for some forests. This data was last updated in October 2009.

Using the MAF large forest owners' map, forest blocks owned by large-scale forest owners were identified and removed from the data to give a separate GIS layer of 522 small-scale forests. Forest blocks without a known planting year were further excluded, reducing the number of small-scale forest blocks to 252.

Small-scale forest sampling

A sample of 58 radiata pine blocks was randomly selected by using the probability proportional to size sampling method. This technique was considered to be the most appropriate sampling technique as the sampling units vary considerably in size. The technique ensures that any single hectare in the small-scale estate has the same probability of being selected. The sample blocks vary in area between 2.3 hectares and 566.2 hectares with an average of 96.1 hectares.

Harvest volume estimation

According to the National Exotic Forest Description (NEFD, MAF, 2011) 82 per cent of the radiata pine area in Whanganui District is pruned or will be pruned. Because the actual silviculture for individual blocks was unknown it was assumed that all blocks had been pruned. It was also assumed that all small-scale blocks are equally productive and follow the radiata intensive young yield table developed for the NEFD wood availability forecasts (MAF, 2009) for the western southern North Island. This estimates a total recoverable volume at age 30 years of 521 cubic metres per hectare, broken down by 130 cubic metres per hectare pruned, 304 cubic metres per hectare unpruned, and 87 cubic metres per hectare pulp logs. In order to generate volume by market log grades, the radiata pine calculator (NZTG 2003) was used with inputs calibrated so that the outputs mimicked the NEFD total recoverable volume and aggregate log grade volumes. The market log grades used are shown in the table.

Log grades estimated using radiata pine calculator

Grade	Minimum small end diameter (mm)	Length (metres)	Maximum branch size (cm)
Pruned	350	4.9-6.1	0
S30	300	4.9-6.1	6
S20	200	4.9-6.1	6
A	350	4-6	10
K	200	4	10
Pulp	100	3.7-6	N/A

Estimation of delivered wood cost

The Visser cost model was used to estimate the delivery cost for each sample block at each rotation age from 20 to 50. The model is based on empirical harvesting cost data from operations throughout New Zealand, but combines experience and basic mathematical functions to ensure the model is robust. It provides indicative costs in dollars per tonne for three main components that make up the total delivered cost – harvesting, roading and log transportation to market. Each cost component value is a product of a regression using some physical factors of the site as dependent variables.

Inputs to the model are –

Harvesting –

- Harvest area
- Expected volume per hectare
- Average slope of terrain
- Number of log sorts to be cut.

Roading –

- Length of new road in hilly to steep terrain
- Length of new road in flat to rolling terrain
- Length of existing road needing improvement
- Length of road requiring maintenance during harvest
- Number of landings.

Transportation –

- Distance to be travelled on forest or unsealed road
- Distance to be travelled on sealed public road.

Generation of inputs for Visser cost model

Harvesting –

- Harvest area was calculated as 90 per cent of the forest block area as it was assumed that this percentage was stocked
- Expected volume per hectare was taken to be the total recoverable volume obtained from the radiata pine calculator calibrated to the yield table. For a 30 year rotation this was 521 cubic metres per hectare
- To obtain the average slope for each block, a surface analysis on was carried out using the spatial analyst extension in ArcGIS 9.3
- Number of log sorts to cut was assumed to be 12 for all blocks, an average value for New Zealand radiata pine plantation forests.

Roading –

Two road network shape files were downloaded from LINZ –

- Road centreline layer from the LINZ 1:50,000 NZTopo database
- NZ walking and vehicle track.

Both sets of data were last updated in March 2010. These were merged together to form road network data for this study. Input variables for the roading cost model were extracted from this road network data via the ArcGIS extension network analyst ArcGIS 9.3. A hierarchy function was set up for the road surface classes so that sealed road type is preferred to be travelled on over unsealed roads.

Distance of existing road needing improvement
There were three road surface types in the road network data – sealed, metalled with gravel or shingle, and un-metalled dirt or clay. The length of existing un-metalled roads that would be used at harvest, either within the forest or outside the forest to connect to the public road, was identified and measured for each stand on GIS.

New road construction
There are two types of new roads to be built –

- Roads from the forest block to the nearest existing road
- Spur roads inside the block to provide access to the landings.

The required length of access roads outside the forest was simulated on GIS so that all forests would be connected to the existing road network. For the in-forest roading, the required road length was estimated as a function of the harvest block area using a relationship developed from 19 recently harvested sites. For blocks with existing infrastructure in place, the length of new track required was calculated by subtracting the existing length from the estimated required length.

The roading cost model takes different slope classes into account. Using the derived slope surface, the length of roads in flat to rolling terrain, and in hilly to steep terrain, was calculated. For this project, forests with an average slope greater than 30 per cent were considered hilly to steep whereas the stands with average slope less than 30 per cent were considered flat to rolling.

Length of road requiring maintenance during harvest
It was assumed that all roads required maintenance either during harvest or post-harvest to restore them to pre-harvest conditions.

Number of landings
The number of landings was assumed to be one landing per six hectares of forest, an average value for New Zealand woodlots.

Transportation –

Information used for transport cost estimation was –

- Location from which logs from each forest block will be transported
- Location of sawmills and ports log destinations
- Road network file.

The origin for any route created within network analysis must be a single point. As such, centroids were created for the polygon shape files representing forest blocks. MAF provided a shape file displaying locations and size class of major sawmills and export ports. Based on advice from forest company harvesting staff in the region, estimates were made of the proportion of total recoverable value that goes to different destinations. It was assumed that these proportions apply to all blocks. The average distance, broken down between sealed and unsealed roads, from forest to market was calculated for each block.

Percentage of total recoverable volume transported to each destination

Destination	Percentage
Tangiwai	17
Karioi	15
New Plymouth	4
Waverley	8
Fielding	6
Dannevirke	8
Masterton	8
Levin	5
Wellington port	29

Optimum rotation age

The optimum rotation age for each block was estimated by finding the age between 20 and 50 years that gave the maximum net present value at a discount rate of eight per cent. Estimated harvesting, roading and transportation costs for each block were used together with standard assumptions about yields, at-market log prices (MAF 12Q prices at September 2010), silvicultural costs, annual costs and land rental.

Results

Initially the total cost at harvest (harvesting, roading and transportation) is estimated for a 30-year rotation to give an indication of the relative difficulty of harvesting. Then the total harvest cost at the optimum rotation age for each block is estimated. Finally the potential effect of the ETS is considered.

Harvesting cost

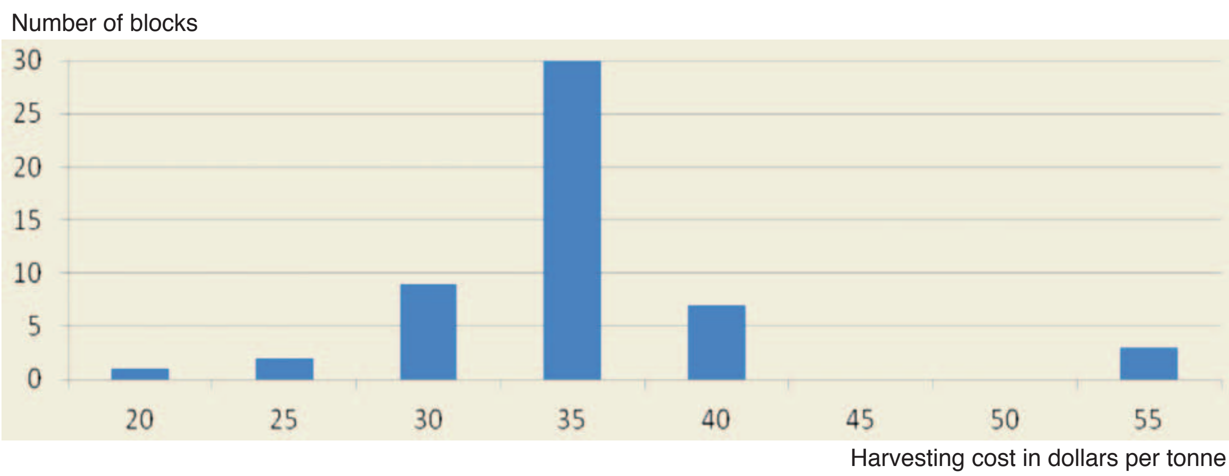
The mean estimated harvesting cost for the sample forest blocks at age 30 years is $35 a tonne. The median is also $35 a tonne, with a range from $21 to $56 a tonne. Most values are concentrated between $30 and $40 a tonne. The Visser cost model estimated three blocks would have harvesting costs in excess of $50 a tonne. This is due to a combination of small size between 2.3 and 3.4 hectares, and steep slopes form 31 per cent to 47 per cent, both of which affect harvest costs significantly.

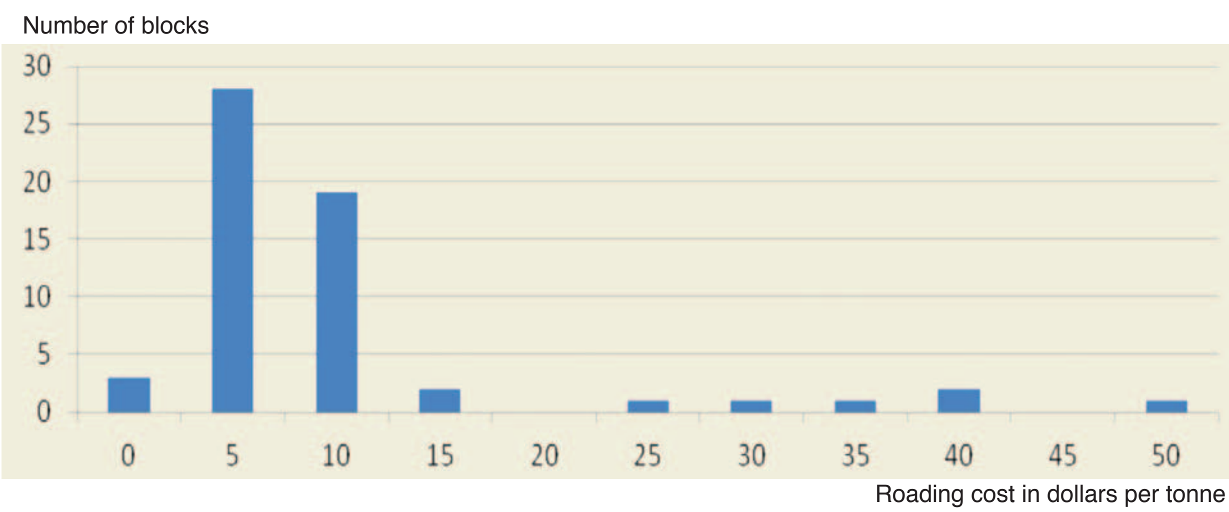
Higher average slopes indicate a need for cable logging, which is inherently more expensive than ground-based logging. Harvest areas smaller than five hectares incur a very high cost per tonne for moving the crew in and out of the stand. This effect is much reduced in a stand of about 10 hectares.

Roading cost

The estimated roading cost at age 30 years has a mean value of $10 a tonne, with a median of $7 a tonne, and ranges widely from $2 to $50 a tonne. However, roading costs for most blocks is less than $15 a tonne. There are six blocks with unit roading cost over $20 a tonne –

- Three blocks on steep terrain have a high roading cost being spread over a very low total harvest volume of 2.3 to 3.4 hectares
- Two blocks of 11.7 and 12.4 hectares on steep terrain have extensive roading requirements to connect to the public road network
- One block has a combination of small size at 3.7 hectares and a long distance of new road required to connect with a public road, although moderated by a lower average slope of 16 per cent.

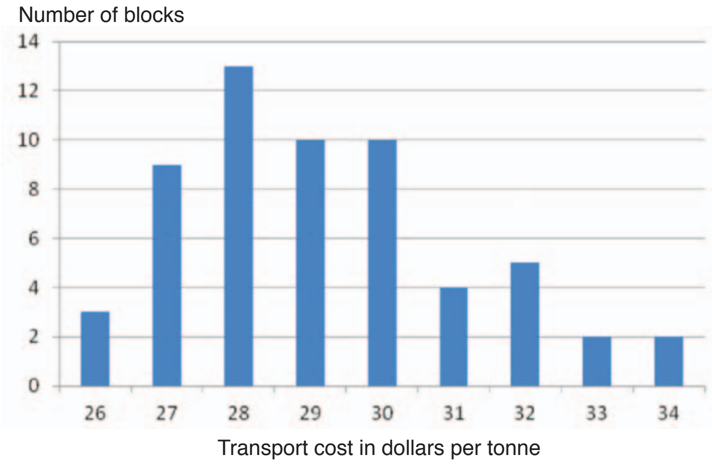




Distribution of roading cost for 58 sample blocks with harvest at age 30 years – values on graphs are mid-points for the range represented by each column.

Transportation cost

We assume that logs from all forest blocks go in the same proportions to the same markets. This general approach results in low variability in transportation distances across all forests. The distribution of the transportation cost at age 30 years is within the range of $26 a tonne and $34 a tonne with an average value of $29 a tonne.



Distribution of transportation cost for 58 sample blocks with harvest at age 30 years – values are mid-points for the range represented by each column

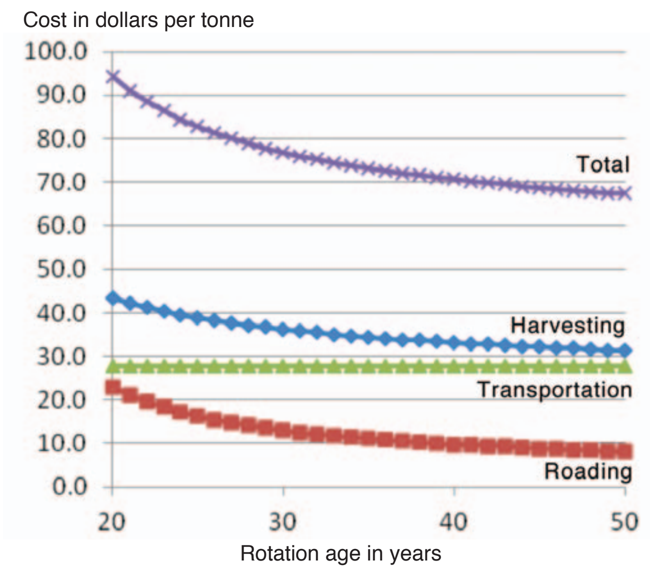
Total costs at age 30 years

The average total cost at harvest, assuming harvest at age 30 years, for the sample forest blocks is $75 a tonne with a median $71 a tonne. The cost of most forests is within a range of $60 and $85 a tonne. This is a result of most common harvesting being $30 to $40 a tonne, roading $5 to $15 a tonne and transport costs $25 to $30 a tonne. The block with the lowest total cost at $53 a tonne is large at 275 hectares and on flat ground.

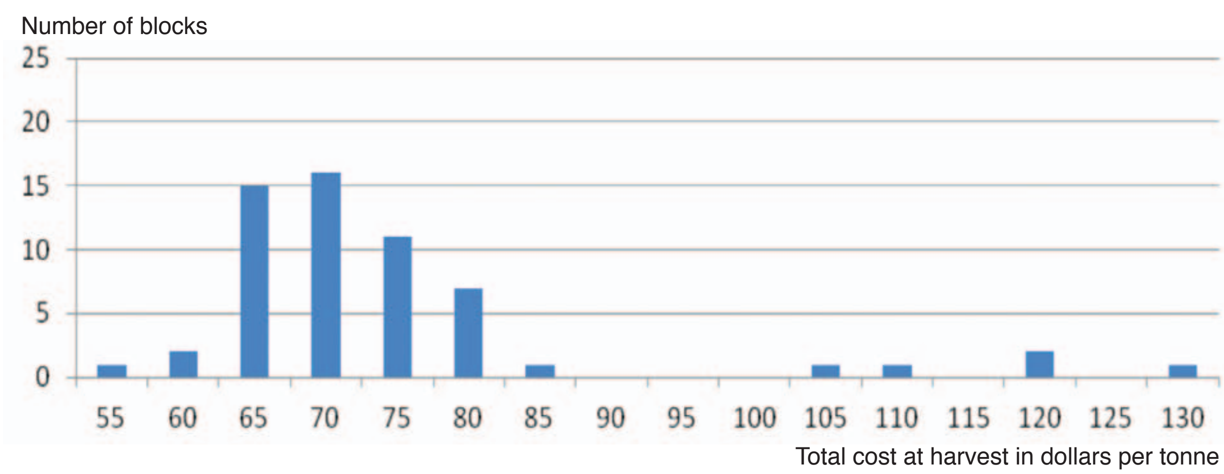
Within the cost distribution there are two components. The majority of blocks, 91 per cent, have costs in the range $53 a tonne to $87 a tonne with an average of $70 a tonne. However there are five blocks with delivered wood cost exceeding $100 a tonne. These blocks are the same set of blocks which had roading costs in excess of $20 a tonne, with the exception of the 12.4 hectare block.

Optimum rotation age

The graph below shows how harvesting and roading costs vary with rotation age for an example block. Harvesting cost decreases with age because of the effect of increasing volume and piece size. Roading cost decreases with age because the same total roading cost is allocated across a greater volume, although the unit transportation cost remains unchanged. The trend in total cost with age will have an influence on optimum rotation age.

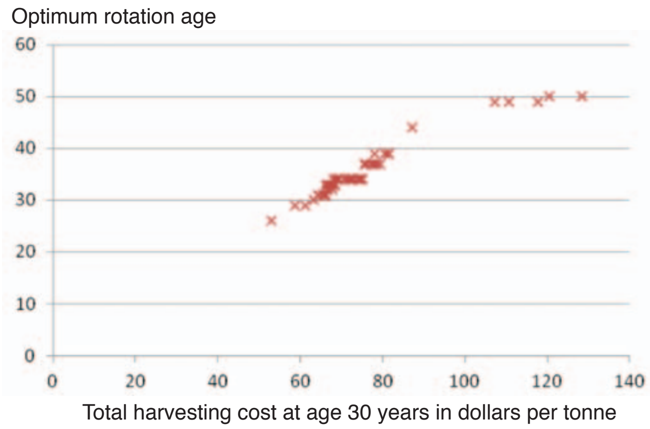


Effect of rotation age on costs of harvesting, roading and transportation for an example block



Distribution of total cost at harvest for 58 sample blocks with harvest at age 30 years – values are mid-points for the range represented by each column.

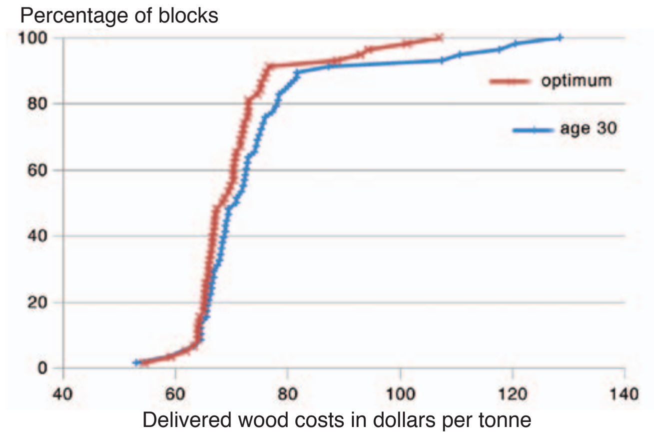
Optimum rotation age varies between 26 and 50 years with most stands having an optimum rotation age in the range 26 to 39 years. Stands on high cost sites have optimum rotation age delayed until 49 or 50 years. As a result the distribution of total cost at harvest at the optimum rotation age has the right hand tail moved to the left with the main change being the reduction in cost for the high-cost sites. However, even with the lower costs there are still two blocks which are in excess of $100 a tonne.



Effect of harvesting difficulty, as measured by total cost of harvest for a 30 year rotation, on optimum rotation age

The table on the top right shows the delivered wood cost for harvest at age 30 years and the optimum rotation age, as cumulative curves. It shows the percentage of blocks which have a total cost less than or equal to the specified level. The delivered cost curves indicate the percentage of small-scale forest blocks that would be profitable to harvest at a given average log price either at the end of a 30-year rotation or at the optimum rotation age. For example, no forest would be profitable to harvest at an average log price under $50 a tonne because all of the blocks have delivered costs exceeding this level.

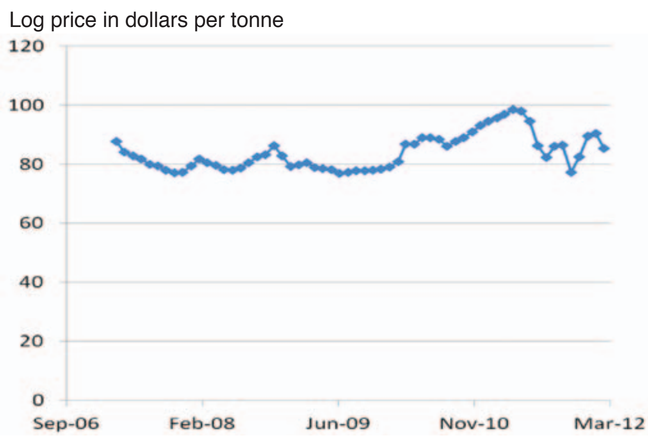
At the September 2010 MAF 12Q log price of $84 a tonne, 90 per cent of the forests can generate positive stumpage values with a 30-year rotation. This increases to 91 per cent with harvest at the optimum rotation age.



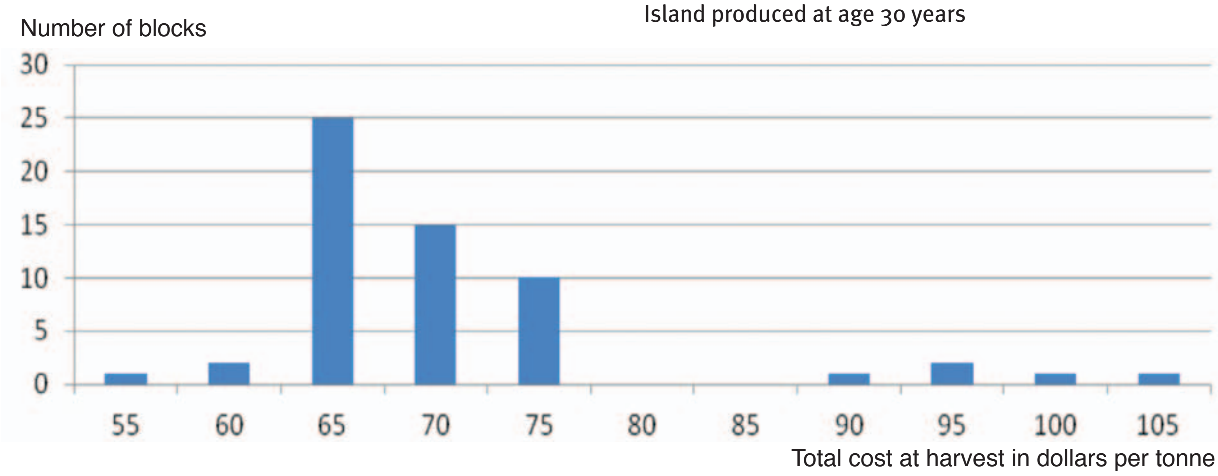
Cumulative curve of the distribution of total delivered wood costs with harvesting at age 30 and optimum rotation age

Log prices

The next graph provides some context for the supply or cost of harvest curves calculated. It shows the average log price by month for the southern North Island over the five year period from April 2007 to



Weighted average log price per month for the southern North Island produced at age 30 years



Distribution of total cost at harvest when each block is harvested at the optimum rotation age

March 2012. Although the series is calculated using the log grade mix for a 30-year rotation, there is not a big age effect. For example, the weighted average price for a 50-year rotation is only about $1.50 a tonne higher.

The average price over the five years is $84 a tonne. Even with log prices at peak levels of the last five years, harvesting the most difficult sites is likely to result in negative stumpage.

Effect of the ETS

According to the New Zealand Land Use and Carbon Analysis System (LUCAS) only 27 of the 58 sample blocks are eligible to enter the ETS as post-1989 forest land. Although only six of the existing stands were planted before 1990, it appears that the LUCAS system has assessed that many of the stands planted since 1989 were on existing forest land. However, in order to illustrate the potential effect of the ETS we have assumed that all 58 blocks are eligible as post-1989 forest land.

The implementation of the ETS results in an increase in average optimum rotation age to 48.2 years, assuming a carbon price of $20 for an NZU. A total of 48 blocks have an optimum rotation age of 49 years while a further five blocks, the most difficult sites, have an optimum rotation age of 50 years. The prolonged rotation age implies a delay in the peak period of future wood supply. However this also depends on the forest owner's intention to harvest and the risk in prolonging the rotation and decision-making based on those risks.

Discussion

Wood supply curves

The delivered wood cost curves are essentially wood supply curves. They give the percentage of blocks which are profitable to harvest at different log prices. The total delivered cost curves consider all 58 blocks together regardless of current age. Although the stands may in practice be harvested in different years and at different ages the curves are indicative of the cost distribution for the small-scale estate in the Whanganui District.

The five blocks with total age 30 and cost over $100 a tonne are generally small blocks on steep sites that have high harvesting costs of $40 to $56 a tonne and high roading costs of $33 to $50 a tonne. The optimum rotation age for these blocks is at least 49 years when delivered wood cost is reduced but is still in the range $89 to $107 a tonne. Given that average market prices for logs over the last five years have been $84 a tonne it is probable that these blocks will only be harvested at old ages and only at times of above average log prices. The two blocks with delivered wood cost in excess of $100 a tonne are unlikely to be economic to harvest even at the optimum rotation age. Five to 10 per cent of the area of small-scale blocks in the Whanganui District may never be harvested.

Simplifications

A number of simplifications have been made in this study.

- The same regime and harvest volume has been assumed for each block. In reality volumes will vary by stand and, given the effect of volume on harvesting and roading cost, the variation in delivered wood cost will be greater than that shown here. The lower value of unpruned stands means that a greater proportion of them will have marginal stumpages.
- The same market allocations have been assumed for volumes harvested from each block. They are indicative only and will change, for example, the mill at one of the assumed destinations was closed recently. The allocations will also vary by block depending on the buyer and markets that they supply.

In spite of these simplifications, the generic inputs used here do indicate the probable distribution of costs associated with harvesting the small-scale estate in Whanganui District.

Visser costing model

The Visser costing model was developed using data from the large-scale estate where harvesting blocks are usually in the range of 10 to 200 hectares. It is necessary to consider how accurate this model is, particularly for the smaller blocks in the small-scale owners' estate. Another study has been started to test the model in estimating costs for harvesting small woodlots – those being less than 20 hectares. Results to date indicate that the Visser costing model under estimates by about five dollars a tonne the cost of harvesting, but over estimates the cost of roading by about three dollars a tonne.

This survey was carried out in late 2010 and early 2011 and involved interviewing consultants and resulted in a total of 24 entries. At that time there was a very high demand from export markets. As such, many woodlot owners were prepared to pay higher harvesting rates to take advantage of the high export log prices.

It also appears that woodlot owners are prepared to accept lower roading standards, with none upgrading the road in the forest. Only nine of the 24 either built or upgraded the road leading to the woodlot. Lower road standards can affect environmental performance but also site accessibility during inclement weather. Increased risks of delays caused by road closure can then result in higher harvesting costs, which may be factored in by contractors working on woodlots. The Visser costing model was created to reflect costs associated with professional harvest operations and was therefore not adjusted. With slightly higher harvest costs being balanced out by lower roading costs, overall the Visser costing model appears to be able to accurately estimate costs for woodlots for the purpose of this study.

Rotation age

Rodenberg and Manley (2011) found that most small-scale forest growers intend harvesting radiata pine between ages 24 and 35 years with an average low of 28 years and an average high of 30 years. Therefore the base case of 30 years used in this study appears reasonable. The optimum rotation age, calculated assuming a discount rate of eight per cent, can be considered to be a theoretical estimate. In reality the target rotation age for small-scale owners will depend on the financial and non-financial aims of the owners. Nevertheless the two approaches provide a reasonable range of delivered wood cost, particularly for difficult blocks.

Positive stumpage

An implicit assumption in this analysis is that forest growers will only harvest if they expect a positive stumpage. Although a forest grower might harvest at a loss they are only likely to do so if they perceive high running costs or have a better use for the land, where continuing with the tree crop has a high opportunity cost.

Positive stumpage may be a necessary but not sufficient condition for harvesting by forest growers who may wish to delay harvesting to try and recoup costs incurred in establishment, tending and overheads. Although these costs may be sunk they may set an expectation about the minimum stumpage that a forest grower is prepared to harvest for.

ETS

The ETS would have a major effect on harvest age if –

- All area was eligible
- All owners with eligible land opted into the ETS
- Carbon price was $20 a tonne.

Given that none of these conditions fully apply, the ETS will have a lesser effect. Assuming that a functioning carbon market develops and persists, the ETS will tend to extend rotation age. The biggest impact may be to result in stands with marginal stumpage not being harvested.

Acknowledgements

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