What proportion of the small-scale owners' estate in the North Island is likely to be harvested?

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Abstract

The small-scale forest estate, much of which was planted in the 1990s, will provide an increasing proportion of New Zealand's harvest volumes over the next decade. However there are questions about the proportion of this estate that will be harvested. Some small-scale forests may not be economic to harvest because of size, location and terrain.

As part of Management Case Study 2014, Bachelor of Forestry Science (BForSc) students estimated the delivered wood cost (DWC) – total of harvesting, roading, transportation and marketing costs – for a sample of 60 small-scale forest blocks in each of seven regions covering the North Island. This analysis took into account the size, slope, location and roading requirements of each block and assumed a rotation age of 28 years. There is a wide distribution of DWCs in each region. Between 0% and 2.9% of the blocks in a region (North Island average 1%) had DWCs that exceeded the maximum export log price for the four years to March 2014. An additional 1.2% to 6.7% (North Island average 3.5%) of blocks had costs that were less than the maximum export log price but exceeded the average export log price. Some 30% to 73% (North Island average 46%) of blocks had costs that were less than the average export log price but exceeded the minimum export log price.

Consequently while there is very small proportion of small-scale blocks that are unlikely to be harvested, the viability of harvesting a substantial proportion of the small-scale estate is very sensitive to log prices. In addition, when typical silvicultural, overhead and land rental costs are included and average log prices are applied, 11% of blocks had a negative stumpage or a negative internal rate of return (IRR) indicating that replanting is unlikely unless above-average prices are achieved.

Introduction

Small-scale forest owners (less than 1,000 ha) are estimated to own 536,000 ha out of the total New Zealand plantation estate of 1,747,000 ha (MPI, 2014). This portion of the estate is becoming increasingly important for wood production. Wood availability forecasts indicate that, '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). However these forecasts do not account for economic factors – neither future market conditions nor the cost of production is explicitly included. 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.'

In a case study carried out in Whanganui District by Park el al. (2012), the DWC (total of harvesting, roading and transportation costs) was estimated for a sample of 58 small-scale forest blocks taking into account the size, slope, location and roading requirements of each block. The study indicated that 5% to 10% of the area of small-scale blocks in the Whanganui District may never be harvested.

The study reported here is an extension of that study. The purpose of this study is to estimate the proportion of the small-scale resource in the North Island that could be harvested at different log price levels. It was undertaken by final year BForSc students as part of Management Case Study in 2014.

Initially, key characteristics of the small-scale estate in each of seven regions are described. Then the total DWC is estimated for a sample of forest blocks assuming a rotation age of 28 years. 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 IRR for each of the sample blocks is estimated to indicate whether replanting is likely to occur.

Methods

Regions

There were 21 students in the class working in groups of three. Each of the seven groups analysed a different region (Figure 1). Regions consisted of the five National Exotic Forest Description (NEFD) Wood Supply Regions in the North Island with Central North

Island (CNI) and Southern North Island (SNI) split into two along territorial authority boundaries:

1. Northland
2. CNI-West
3. CNI-East
4. East Coast
5. Hawkes Bay
6. SNI-West
7. SNI-East.

Resource characteristics

Orthorectified satellite imagery was provided for the North Island by MPI. The 2012 Land Use and Carbon Analysis System (LUCAS) map provided by the Ministry for the Environment was used to indicate the area and location of forest land. Areas of large-scale plantation forest (>1,000 ha) were removed using a mask provided by MPI. The resulting LUCAS small-scale forest data layer was analysed to estimate the area, slope and distances to the nearest road and closest export log port for each small-scale forest polygon in each region. These factors were established through spatial analysis in ArcGIS. As the analysis found that LUCAS areas consistently over-predicted net stocked area, results are reported as proportions rather than absolute values.

Small-scale forest sampling

A sample of 60 radiata pine blocks was randomly selected for each region by using the probability proportional to size (PPS) sampling method. This technique was considered to be the most appropriate sampling technique as the sampling units (small-scale forest blocks) vary considerably in size. The technique ensures that any single hectare in the small-scale estate has the same probability of being selected.

Harvest volume estimation

Summary statistics were provided for each region by MPI based on ETS FMA (Emission Trading Scheme Field Measurement Approach) plots. These included:

- Site index – mean and standard deviation
- 300 index – mean and standard deviation
- Stocking – median as well as 15th and 85th percentiles
- % of area pruned. (In subsequent analysis the area in each sample block was assumed to be pruned/unpruned in the proportion indicated by the FMA plots in the region. Analysis was undertaken for both the pruned and unpruned portion with results weighted by the relative area.)

These were input to the Radiata Pine Calculator (NZTG, 2003) in order to generate volume by market log grades. The log grades used are shown in Table 1.

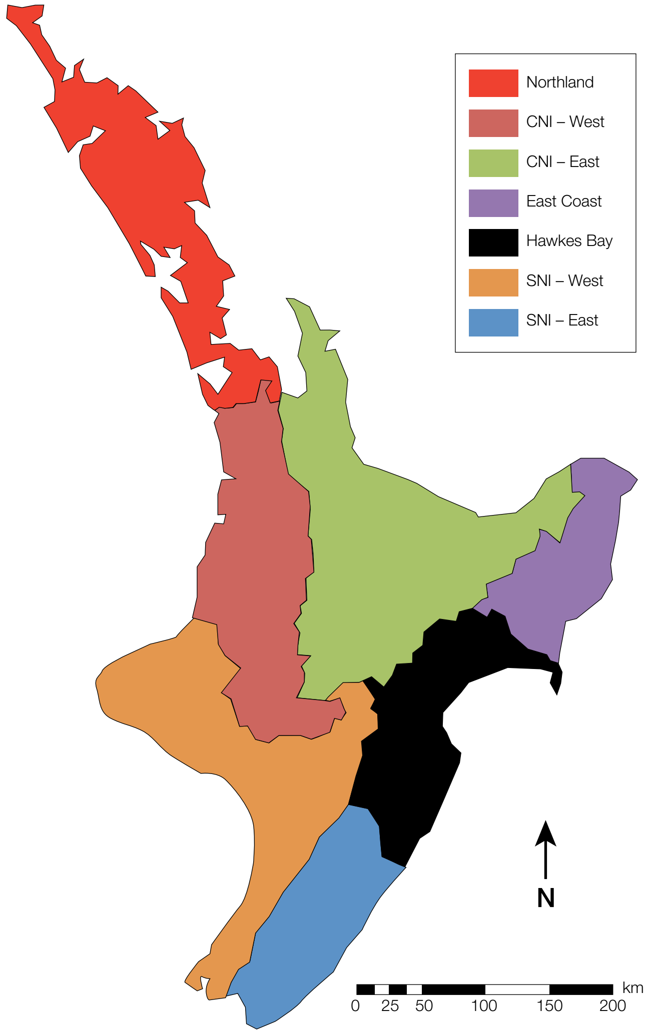

Figure 1: The seven regions analysed in the study

Table 1: Log grades estimated using Radiata Pine Calculator

Grade	Minimum SED (mm)	Length (m)	Maximum branch size (cm)
Pruned	350	4.1–6.1	0
S30	300	4.9–6.1	6
S20	200	4.9–6.1	6
A	300	4	10
K	200	3.6–4	15
KI	260	4	25
KIS	100	4	25
Pulp	100	3.7–6.1	25

In order to allow for variation in yields a total of nine yield tables were generated for each region for both a pruned and unpruned regime. The nine yield tables are based on three different site productivities and three different final crop stocking with values selected so that each yield table broadly represents one ninth of the resource:

Site productivity (for both 300 index and site index, i.e. both vary together)

- Mean – 1 standard deviation
- Mean
- Mean + 1 standard deviation

Stocking

- 15th percentile
- 50th percentile
- 85th percentile

Markets

It was assumed that all logs will be exported through the nearest export log port, with the exception of the pulp grade which is transported to the nearest pulpmill or MDF plant or left in the forest. The KIS specification essentially takes what would otherwise be a domestic pulp log but needs to be reasonably straight. It was assumed that what is left in the pulp grade cannot be exported and must either go to a domestic plant or be left in the forest.

Estimation of delivered wood cost

The Visser Cost Model (VCM) was used to estimate the delivery cost ($/tonne) for each sample block at age 28 years, broken down into the three main components that make up the total delivered cost: harvesting, roading and log transportation to market. The VCM is based on empirical cost data from operations throughout New Zealand, as well as experience. It uses physical factors of the site and stand to estimate the cost components. For details on model inputs see Park et al. (2012). Key inputs of slope, distance to public road and distance to port were estimated for each sample block using ArcGIS. An additional cost of $5/tonne has been included for the cost of log sales administration and marketing.

Log prices

Monthly Agrifax log prices for each grade from March 2010 to March 2014, converted to real $ December 2013, were used to provide context to the DWC results.

Classification of blocks

The rules adopted for classifying blocks:

- If the DWC is greater than the maximum log price (over the last four years) a block is *uneconomic* to be harvested
- If the DWC is greater than the average log price (over the last four years) but less than the maximum price a block is *marginal* for harvesting
- If the DWC is greater than the minimum log price (over the last four years) but less than the average log price a block will *probably* be harvested
- If the DWC is less than the minimum log price (over the last four years) a block is *economic* to be harvested.

Internal rate of return

The IRR was calculated for each of the sample blocks using:

- A rotation age of 28 years
- The silviculture costs in Table 2
- The same yield assumptions described above
- DWCs described above
- Average log prices for the period March 2010 to March 2014
- Annual overhead cost of $80/ha/yr and annual land rental of $70/ha/yr.

Table 2: Silviculture costs used to calculate IRR

Age	Operation	Cost ($/ha) pruned regime	Cost ($/ha) unpruned regime
0	Land prep	500	500
0	Pre-plant spray	150	150
0	Planting	850	850
1	Releasing	200	200
5	Low prune	750	
7	Medium prune	700	
8	High prune	500	
9	Thin to waste	600	500

Results

Resource characteristics

The preliminary analysis of the LUCAS small-scale planted forest polygons is summarised in Table 3. Regions that stand out in terms of averages are:

- Slope
  - Northland and Hawkes Bay have lowest average slopes
  - East Coast, SNI-West and SNI-East have highest average slopes
- Distance to public road
  - Northland has the shortest distance followed by SNI-West and CNI-East
  - SNI-East has the greatest distance followed by East Coast
- Distance to port
  - Hawkes Bay has the shortest distance followed by East Coast
  - CNI-West has the longest distance followed by SNI-East, SNI-West and Northland.

Table 3: Average slope, distance to public road and distance to port for the LUCAS small-scale polygons in each region – averages are calculated on an area-weighted basis

	Slope (%)	Road distance (m)	Port distance (km)
Northland	19	393	127
CNI-West	26	721	150
CNI-East	22	537	110
East Coast	33	1235	88
Hawkes Bay	22	715	69
SNI-West	33	526	127
SNI-East	30	1306	136
North Island	26	694	120

Regions have different slope distributions. Northland and Hawkes Bay have distributions skewed towards lower slopes while East Coast, SNI-West and SNI-East are skewed towards higher slopes. Some 9% of area in SNI-West, followed by 5% in East Coast and 4% in SNI-East has a slope over 50%.

General average slope cut-offs for different harvest systems are:

- Wheeled skidder <30%
- Tracked machines <40%
- Cable systems >40%.

These limits were used to classify the percentage of area in each slope category (Table 4). Any block that has terrain over 40% slope is likely to have a cable yarding system used, even if it is only a small percentage of the total area. The percentage of area that will require harvesting by cable system will therefore be in excess of 17%.

Table 4: Proportion of small-scale area in different slope classes

	<30%	30–40%	>40%
Northland	86	12	2
CNI–West	62	25	13
CNI–East	77	15	8
East Coast	37	42	22
Hawkes Bay	69	21	9
SNI–West	33	24	43
SNI–East	50	39	11
North Island	59	23	17

There are different distributions of the distance to public road. The majority of forest area in Northland, SNI-West, CNI-West and CNI-East is within 500 m of a public road. The distributions for East Coast and SNI-East are flatter. Some 23% of East Coast small-scale area and 21% of SNI-East area is over 2 km from a public road.

There are marked differences between regions in the distribution of distance to port (Figure 2). East Coast and Hawkes Bay have relatively short distances while CNI-West and SNI-East have long distances. Some 10% of area in CNI-West and SNI-West, together with 7% of area in Northland, is over 200 km from a port.

Harvest volume

Average harvest volumes expected at age 28 exceed 700 m^3/ha apart from Northland (Table 5). These volumes are high relative to average volumes currently being recovered. The national average harvest volume in 2014 for radiata pine was 519 m^3/ha at 28.9 years (MPI, 2014). The higher volumes shown in Table 4 are driven by the site productivity and stocking of the ETS FMA plots in each region.

Table 5: Estimated total recoverable volume (TRV m^3/ha) at age 28 years for each region (estimates are based on the mean site index and 300 index and median stocking for ETS FMA plots in each region)

	Pruned (m^3/ha)	Unpruned (m^3/ha)
Northland	650	694
CNI-West	746	765
CNI-East	730	751
East Coast	774	795
Hawkes Bay	771	792
SNI-West	702	726
SNI-East	731	765
North Island	716	745

Delivered wood cost

Harvesting cost

Harvesting cost follows a similar distribution for all regions. SNI-West has a higher percentage of area with harvesting cost of $15-$20/tonne because six of the samples were in blocks of moderate size (82 to 343 ha) and on flat sites. Conversely, CNI-West had a higher percentage of area with harvesting cost of $40-$45/tonne because of the proportion of samples that were in small blocks and on steep sites. All regions have a peak at $25-$35/tonne with regional averages between $29-$31/tonne. The average harvesting rate for ground-based systems in 2014 for large-scale forests was $26/tonne (Visser, 2014).

Roading cost

The majority (74% to 89%) of samples in all regions have a roading cost of less than $10/tonne. Some 9% to 23% had roading costs ranging from $10-$25/tonne, which becomes a significant component of the overall delivered cost. A few outliers (1% to 6%) have a very high roading cost (>$25/tonne). These outliers are in small steep blocks with a substantial length of new road required to connect the block to a public road.

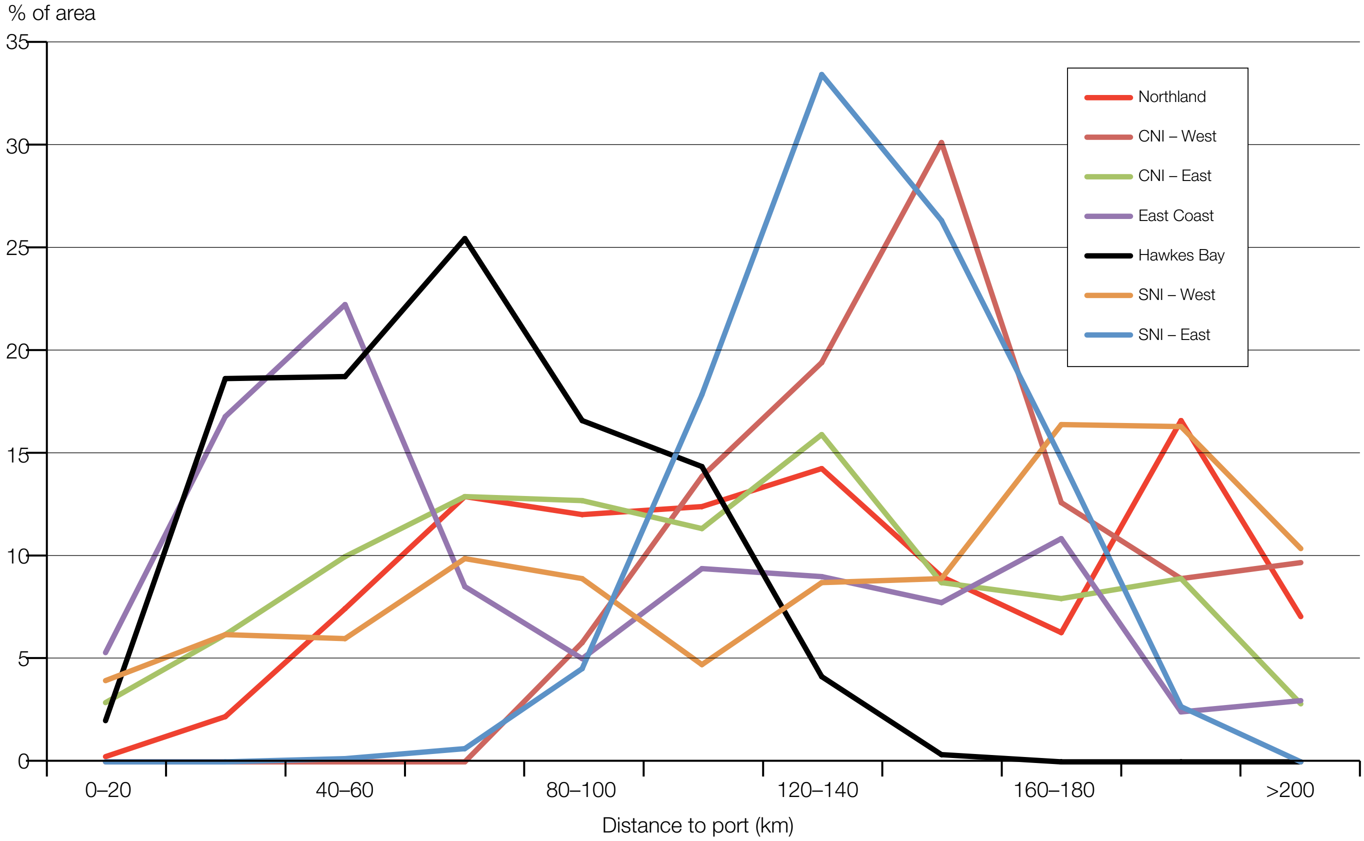

Figure 2: Distribution of distance to port for the Lucas small-scale polygons in each region

Transportation cost

The distribution of transport costs vary by region depending on the location of forest relative to ports. Hawkes Bay and East Coast have relatively low transport costs while CNI-West and SNI-East, as well as SNI-West and Northland, have relatively high transport costs. These relativities are in line with the relativity of distance to port shown in Figure 2.

Total harvesting, roading, transportation and marketing costs at age 28 years

There are marked differences in DWC between regions, both in terms of average (Table 6) and distribution (Figure 3). The key driver of the differences is transport cost. A secondary driver is roading cost. In contrast all regions have average harvesting cost in the range $29-$31/tonne.

Log prices

Figure 4 provides some context for the DWC distributions. It shows the average log price by month for Gisborne/Hawkes Bay over the four-year period from March 2010 to March 2014. The series are calculated using the log grade mix for a 28-year rotation for both pruned and unpruned regimes in the Hawkes Bay region.

Table 6 : Average costs ($/tonne) for the samples in each region with harvesting at age 28 years

	Harvesting	Roading	Transport	Marketing	Total
Northland	30	6	28	5	69
CNI–West	30	7	39	5	82
CNI–East	30	7	27	5	69
East Coast	30	10	19	5	65
Hawkes Bay	31	9	19	5	64
SNI–West	29	7	32	5	73
SNI–East	30	8	33	5	76
North Island	30	8	29	5	72

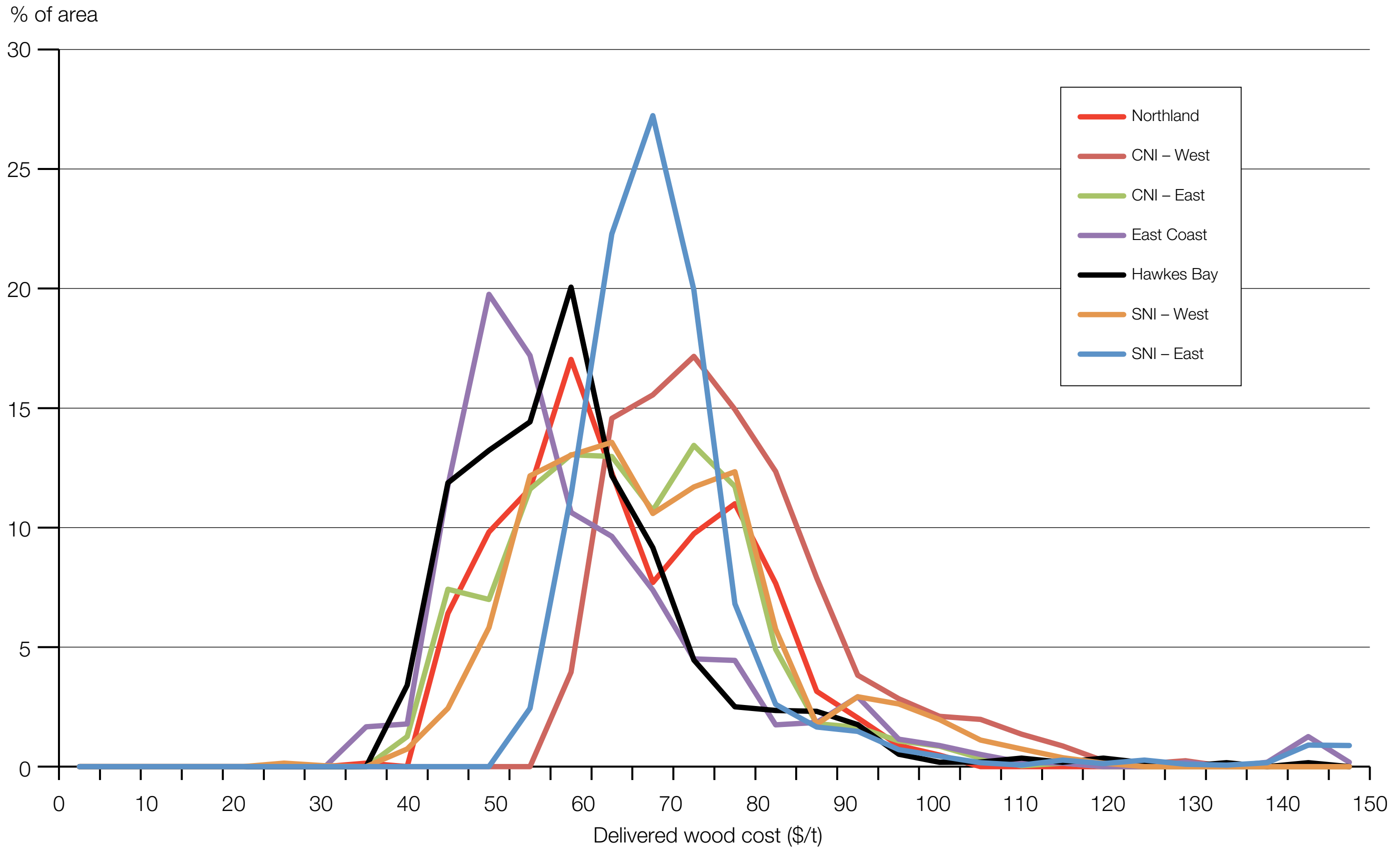

Figure 3: Distribution of total cost at harvest for each region with harvest at age 28 years

Table 7: Minimum, mean and maximum log price ($/tonne – at wharf/mill) for log mix produced at age 28 years for (a) pruned and (b) unpruned regimes (log grade prices are monthly prices from AgriFax series and prices are real $ December 2013)

	CNI Pruned regime	CNI Unpruned regime	Non-CNI Pruned regime	Non-CNI Unpruned regime
Minimum ($/tonne)	78	70	69	63
Mean ($/tonne)	108	98	101	91
Maximum ($/tonne)	129	121	119	112

Table 8: Delivered wood cost (DWC) at age 28 relative to minimum, mean and maximum log prices over the period March 2010 to March 2014 (numbers are the percentage of samples in each region that have DWC in each class)

	Economic DWC<Min	Probable Min<DWC<Mean	Marginal Mean<DWC<Max	Uneconomic DWC>Max
Northland	52	46	2.0	0.0
CNI-West	36	57	6.7	0.6
CNI-East	68	30	1.2	0.1
East Coast	68	26	3.4	2.1
Hawkes Bay	71	26	1.5	1.1
SNI-West	42	50	6.5	1.0
SNI-East	21	73	2.3	2.9
North Island	50	46	3.5	1.0

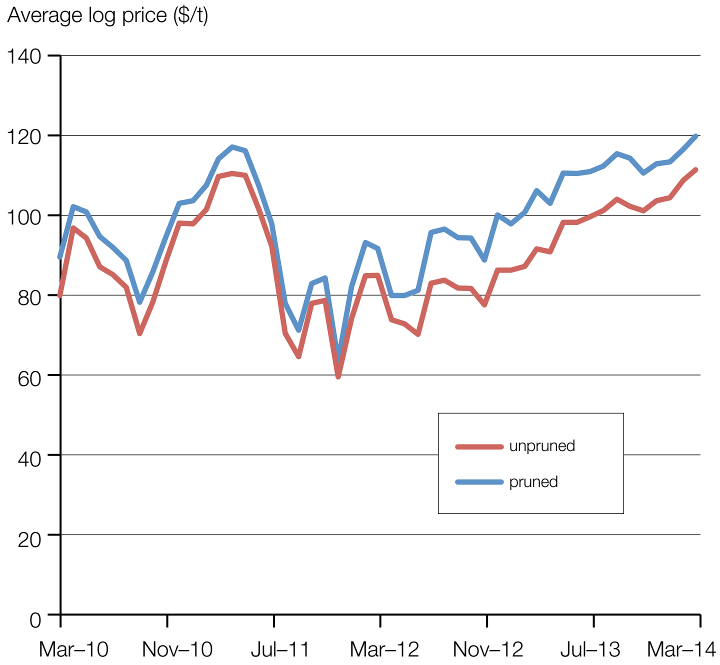

Figure 4: Example of weighted average log price ($/tonne at market) for log mix produced at age 28 years for (a) pruned and (b) unpruned regimes (log grade prices are monthly prices from AgriFax Gisborne/Napier series and prices are real $ December 2013)

The minimum, mean and maximum log price was calculated for each region for the four years to March 2014. As these values were similar for all regions apart from the CNI, common values have been used for non-CNI regions. Separate values have been used for the CNI-West and CNI-East. These prices are higher because of lower costs associated with exporting via Tauranga. Summary statistics are reported in Table 7.

Delivered wood cost at age 28 relative to log prices

From 0% to 2.9% of the samples in each region are uneconomic to harvest while 1.2% to 6.7% are marginal (Table 8). SNI-West has a combined 7.5% in the uneconomic and marginal categories while CNI-West has 7.3%. The North Island averages are 1% uneconomic and 3.5% marginal.

Transport costs if some domestic processing is assumed

Transport costs were also estimated under an alternative scenario that has logs allocated to domestic markets as well as being exported. A split between log exports and local processing was developed that took into account regional characteristics (i.e. the log grades; the number, nature of, and distance to regional processing plants; the distance to the nearest log export port; and respective log prices). At least 30% of the total volume was assumed to be domestically processed. This volume was mainly the higher quality pruned, S30 and S20 grades.

There was little difference in transport costs for East Coast and Hawkes Bay which have major processing plants near the port (Table 9). However there was a substantial difference for those regions where the nearest port is located at the geographic extreme of the region or outside the region. SNI-East and SNI-West were particularly affected with a lesser impact on CNI-West, Northland and CNI-East.

Table 9: Difference in transport distance for each region between assuming (i) 100% export and (ii) >30% of volume domestically processed

	Distance difference (km)	Cost difference ($/tonne)
Northland	18	4
CNI-West	25	5
CNI-East	14	3
East Coast	−5	−1
Hawkes Bay	5	1
SNI–West	31	7
SNI–East	32	7

Internal rate of return

IRRs for each region cover a wide range (Figure 5). As the calculation of IRR used the average log price for March 2010 to March 2014, the percentage of blocks with negative stumpage equals the sum of the last two columns in Table 8 (i.e. all blocks with total DWC in excess of the average log price). For these blocks it is not possible to calculate IRR. The next class of blocks are those which have a stumpage that is positive, but still less than the sum of costs that have been incurred since establishment. Although IRR can be calculated for these blocks it is negative.

Distributions for East Coast, Hawkes Bay and CNI-East are similar and have the highest median IRRs (Table 10). The higher IRRs for East Coast and Hawkes Bay reflect the lower transport costs for these regions (Table 6). The higher IRRs for CNI-East are a reflection of the higher at-wharf prices (Table 7) at Tauranga. Northland, CNI-West and SNI-West all fall into a cluster with lower IRRs. SNI-East has a narrower IRR distribution as a consequence of a narrower distribution of total DWC.

Table 10: Median IRR for each region

	IRR (%)
Northland	5.0
CNI-West	4.5
CNI-East	6.2
East Coast	6.8
Hawkes Bay	6.5
SNI-West	4.6
SNI-East	4.5
North Island	5.2

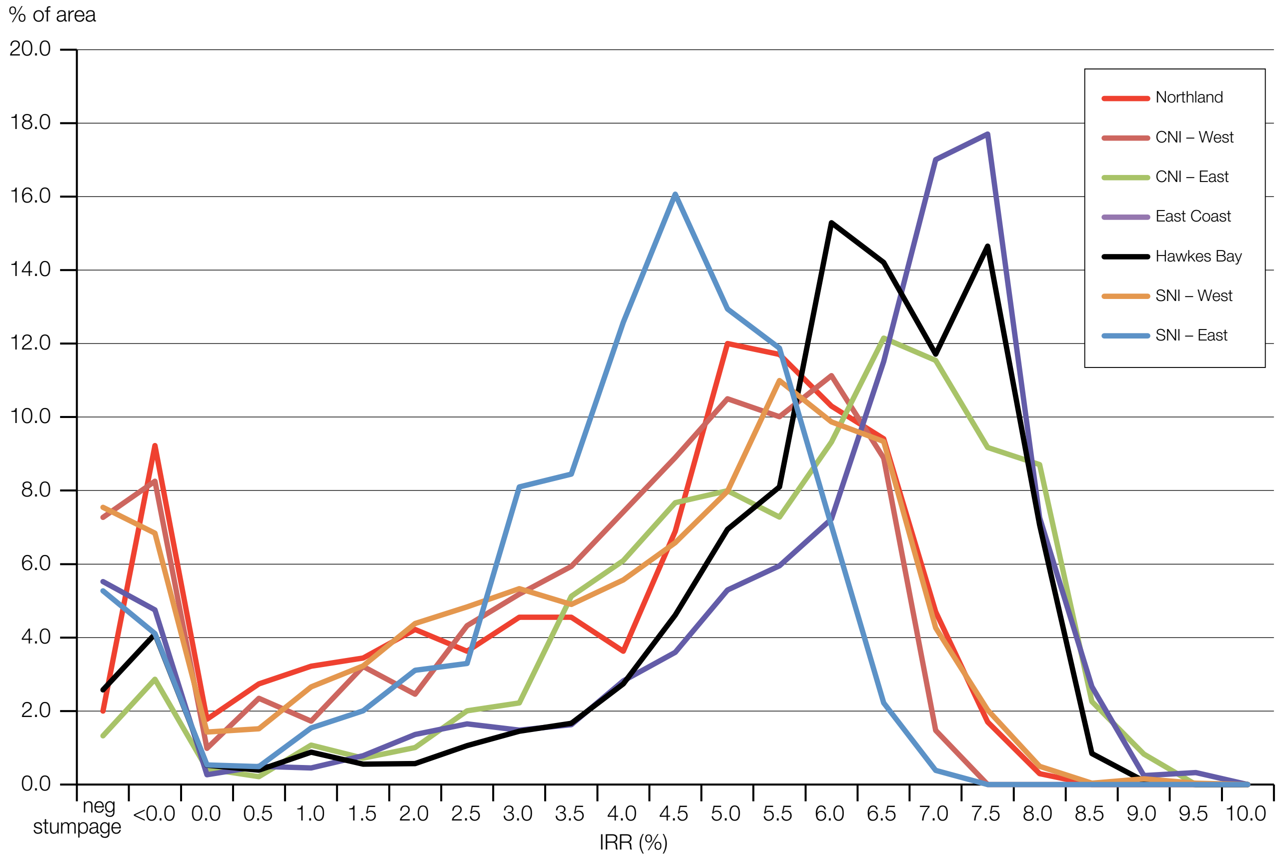

Figure 5: Distribution of IRR for each region with harvest at age 28 years

Discussion

Delivered wood costs

The key finding of this study is that only a small proportion of small-scale forest blocks in the North Island are uneconomic to harvest. On average only 1% of blocks are uneconomic to harvest at age 28 years (regional range 0% to 2.9%), with a further 3.5% marginal (regional range 1.2% to 6.7%). These percentages will reduce if harvesting of high cost stands is delayed to increase the volume over which fixed costs can be allocated. Small-scale owners generally have more flexibility than large-scale owners in age of felling and can leave the stand to grow more volume or to take advantage of log price fluctuation.

The default assumption made was that all small-scale blocks will have to be exported in log form. This was done on the basis that existing processing plants are already being supplied from the existing resource. It is a simplification and results in S30 and S20 logs being downgraded and exported as A and K grades. If domestic processing does expand there will be a reduction in DWC if the additional capacity is located close to forests. However net revenues to the forest grower will not necessarily increase.

The percentage of uneconomic stands is lower than that estimated for the Whanganui District by Park et al. (2012). This earlier study found that 8.6% of sampled blocks would be uneconomic to harvest at age 30 years. In this study we found that only 1% of blocks in SNI-West are uneconomic. The comparison is limited in that SNI-West contains other territorial authorities besides Whanganui District. However the main cause of the difference is log price. Park et al. (2012) assumed that 71% of the harvest volume was domestically processed and used log prices from April 2007 to March 2012. The maximum log price was $99/tonne with an average log price of $84/tonne and a minimum of $77/tonne. We have assumed that all logs are exported (apart from pulp logs). Consequently there has been much greater volatility. In particular, the maximum log price used as a benchmark in SNI-West was $119/tonne for a pruned stand and $112/tonne for an unpruned stand.

Sensitivity to log prices

A large proportion of the small-scale resource falls into the 'probably will be harvested' category, i.e. DWC falls between the minimum and average log prices. On average 46% of blocks are in this category with a regional range 26% to 73%. This illustrates why harvesting is commonly suspended in times of relatively low log prices.

Visser Costing Model

The empirical data that was used to develop the VCM was from the large-scale estate where harvest blocks are typically in the range 10 ha to 200 ha. A survey of consultants in 2010/11 indicated that, while costs varied considerably, the VCM appears to be able to accurately estimate the average total DWCs for woodlots. At the time of the survey harvesting cost tended to be under-estimated, but this was at least partially explained by the small-scale estate owners being prepared to pay a premium to take advantage of the strong export market. Conversely, roading costs were over-estimated as lower quality roads and the associated risk of weather-related delays are often considered acceptable. The VCM was created to reflect costs associated with professional harvest operations and was therefore not adjusted.

Positive stumpage

An implicit assumption in this analysis is that forest growers will only harvest if they expect a positive stumpage. Forest growers are unlikely to harvest at a loss but there is no guarantee that they will harvest if stumpage is positive. In most cases they will be seeking a profit from harvest to 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.

Internal rate of return

The level of IRRs evident in each region helps to explain why there has been relatively little new planting in recent years. Manley (2014) indicates that discount rates around 9% are being applied in forest valuation. There is anecdotal information that investors are seeking similar rates of return on new planting. A very small percentage (0.2%) of the sample blocks had IRR in excess of this rate.

The range of IRRs also has implications for whether blocks will be replanted. Although stumpage may be the key driver for the harvesting decision, whether or not blocks get replanted is likely to depend on whether crop owners feel that they have achieved a satisfactory return. The results indicate that many owners will achieve a reasonable rate of return and are likely to replant. It is apparent, given that most forest is currently being replanted following harvest, that forest owners are prepared to accept rates of return much lower than 9% on replanting. In addition, the IRRs calculated apply to the current rotation. IRRs on replanting are likely to be higher, particularly for blocks for which high roading costs will be incurred in the current rotation.

However there is a proportion of blocks for which owners may be reluctant to invest in re-establishment given the performance of the current crop. The 11% of sample blocks which had a negative stumpage or a negative IRR would fall into this category, unless above-average prices are achieved. Even if most small-scale owners do not explicitly calculate an IRR for their investment, the low (albeit positive) stumpage associated with the negative IRR category will be a deterrent to reinvestment.

Although these blocks might not be replanted, there may be no higher and better land use for some of them. Consequently, they could well regenerate naturally back into forest. A caveat is that this analysis has adopted standard costs. In some cases costs will be substantially lower, particularly if owners undertake silvicultural operations themselves and do not put a cost on their time. Similarly, the assumed annual overhead cost of $80/ha/yr and land rental of $70/ha/yr will be too high in some situations. For some blocks the land will have a lower opportunity cost than $70/ha/yr. A more general caveat is that the analysis is based on the site productivity of the ETS FMA plots in each region. The conclusions made are dependent on the productivity of these sites being representative for the region.

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References

MAF. 2010. *New Zealand Wood Availability Forecasts 2010–2040*. Wellington, NZ: Ministry of Agriculture and Forestry.

Manley, B. 2014. Discount Rates Used for Forest Valuation – Results of 2013 Survey. *New Zealand Journal of Forestry*, 59(2): 29–36.

MPI. 2014. *National Exotic Forest Description as at 1 April 2014*. Wellington, NZ: Ministry for Primary Industries.

NZTG. 2003. Calculators for Radiata Pine and Douglas-fir. *New Zealand Tree Grower*, 24(2): 26.

Park, D., Manley, B., Morgenroth, J. and Visser, R. 2012. What Proportion of the Forest of Small-Scale Owners is Likely to be Harvested: A Whanganui Case Study. *New Zealand Journal of Forestry*, 57(3): 4–11.

Visser, R. 2014. Benchmarking to Improve Harvesting Cost and Productivity: 2013 Update. *Future Forests Research Technical Note HTN05-13*. Rotorua, NZ: FFR.

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