Quantifying the small-scale owners' estate in Canterbury, Otago and Southland

Bruce Manley, Justin Morgenroth, Rien Visser and final year BForSc students of 2015 and 2016

Abstract

According to the National Exotic Forest Description (NEFD), the small-scale forest estate accounts for 520,000 ha of the New Zealand plantation estate of 1,705,000 ha. It is becoming increasingly important for wood production as the large area of 1990s afforestation matures. However, there is uncertainty about the actual area of the small-scale estate, the percentage of area that will be economic to harvest and its potential future yield.

As part of Management Case Study in 2015 and 2016, Bachelor of Forestry Science students mapped the small-scale estate in Canterbury, Otago and Southland. Forest boundaries were mapped in a geographic information system (GIS), based on visual interpretation of aerial photography. It was found that the mapped area of small-scale estate is only 56% of the NEFD estimate in Canterbury, 96% in Otago and 75% in Southland. The total plantation area was estimated by adding the NEFD area for the large-scale estate to the mapped area of the small-scale estate. The Land Use and Carbon Analysis System (LUCAS) plantation area is 59%, 18% and 26% higher in the three regions, respectively. These differences arise because LUCAS is based on gross rather than net area and because of misclassification of land-uses.

By using a standardised spreadsheet that included harvesting, roading and trucking cost estimates for each block, it was also found that only a small proportion of the small-scale estate is likely to be uneconomic to harvest. On average, only 3% of blocks were classified as uneconomic to harvest at age 28 years in Canterbury, 2% in Otago and less than 1% in Southland. A further 10%, 6% and 5%, respectively, were classified as marginal.

Yield forecasts, based on Emissions Trading Scheme Field Measurement Approach (ETS FMA) plots, indicate higher levels of productivity than those used in recent wood availability forecasts. Whether these yields, for a segment of the small-scale estate (i.e. forest growers with over 100 ha participating in the ETS) are representative of the total small-scale estate is unknown.

While this study has provided detail on area, cost and volume for the small-scale estates in Canterbury, Otago and Southland, it has also highlighted that we know surprisingly little about the small-scale estate in New Zealand. We do not accurately know the total area, or where it is located, or the yields it will generate. It is proposed that remote sensing techniques be used, in conjunction with existing databases, to address the questions raised.

Introduction

Small-scale forest owners (less than 1,000 ha) are estimated to own 520,000 ha out of the total New Zealand plantation estate of 1,705,000 ha (MPI, 2016a). This portion of the estate is becoming increasingly important for wood production as the large area of 1990s afforestation matures. Wood availability forecasts (WAFs) indicate that, 'From 2020, the potential wood available from the small-scale owners' forests increases to around 15 million m^3 per annum through to 2035' (MPI, 2016b).

However, there are questions about the actual area of the small-scale estate. The 2016 National Exotic Forest Description (NEFD) survey was sent out to all known forest owners with at least 40 ha of plantation forest (NEFD, 2016a). This survey accounts for 1,436,000 ha. An additional 67,000 ha was derived from a survey of small-scale forest growers carried out in 2004. The final 203,000 ha of area in the NEFD is imputation of new planting in 1992 to 2006. For these years additional areas, not directly captured in the NEFD surveys, were estimated based on annual nursery surveys which measured the sales of planting stock. Imputation was stopped after 2006 because of the low new land planting rate.

For 1992 to 2006, the total number of seedlings sold was used to estimate the total area of planting each year and, by subtracting the area of replanting, the area of new planting was estimated. The national new planting adjustment was calculated by subtracting the new planting area captured in the NEFD survey from this estimate of the total area of new planting. The national new planting adjustment for each year was distributed into territorial authorities (TAs) using the proportions indicated from the new planting collected in the NEFD survey (MPI, 2016a). Consequently, there are questions about the total area of the small-scale estate in New Zealand and its distribution by TAs.

There is also a question about how much of the physical area will be economic to harvest. The Ministry for Primary Industries (MPI) noted in 2016 that:

> *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 (MPI, 2016b).*

In a case study carried out in Whanganui District by Park el al. (2012), the delivered wood cost (DWC or

the 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. Manley et al. (2015) found that between 0% and 2.9% of the blocks in North Island wood supply regions (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.

The study reported here is an extension of these studies. The purpose is to better characterise the small-scale estate in Canterbury, Otago and Southland and specifically to answer:

- What is the area of small-scale estate in each TA within these regions?
- What percentage of it is economic to harvest?
- What is the potential future yield from this estate?

It was undertaken by final year BForSc students as part of Management Case Study in 2015 and 2016.

Initially, the area of the small-scale estate is estimated and compared with NEFD estimates. Subsequently yields are estimated for each region and compared with those used for the recent WAFs. Then the total DWC is estimated for a sample of forest blocks in each TA 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 implications of the findings are illustrated.

Methods

Small-scale forest area mapping

Orthorectified aerial photography was used for forest boundary mapping. For Canterbury, aerial photos were sourced from the Environment Canterbury web map tile service. The orthophotos dated from 2004 to 2013 and had a spatial resolution between 0.4–0.75 m. To check the current status of stands and adjust for major windthrow events in 2013, cross-referencing was done using 2013 and 2014 Landsat8 imagery and Google Earth. For Otago and Southland, orthophotos with a spatial resolution between 0.125–0.75 m, dating from 2004 to 2014, were accessed from the Land Information New Zealand Data Service. Google Earth was used to check the current status of stands digitised from older imagery.

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. A vegetation mask was applied to the study areas to purposely exclude certain land covers from the analysis. The mask included large-scale plantation forests (boundaries provided by forest owners), native forests in the Department of Conservation estate, as well as native forests and grassland with woody biomass from Landcare Research's Land Cover Database (LCDB4). Small-scale forests on all land outside this vegetation mask were systematically mapped in ArcGIS using the following rules:

- The area had to be over 1 ha and greater than 30 m wide, but the 1 ha rule was relaxed when there were contiguous small blocks that added to over 1 ha
- Gaps over 0.1 ha were mapped out
- All mapping was done at a scale of 1:4,000 or greater.

Large-scale owners in Canterbury were defined as Matariki Forests, Port Blakely, Environment Canterbury and District Council forests (Ashburton, McKenzie, Selwyn). For Otago and Southland, the set of large-scale owners used in the regional WAF (MPI, 2014) was adopted: Beaumont Forest, Port Blakely, Cainard Forestry NZ, Calder Stewart Forestry, City Forests, Craigpine Timber, Ernslaw One, Evergrow Properties, Forestry Fund 9 NZ, Invercargill City Council Forests, Landcorp Farming, Matariki Forests, South Wood Export, Southland District Council, Southland Plantation Forest Co. of New Zealand and Wenita Forest Products.

Small-scale forest sampling

Mapping was of the total area in each TA. However, for DWC estimation, a sample of blocks (20 to 100 per TA depending on small-scale forest area) was randomly selected for each TA 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. It meant that some larger blocks could be included in the sample multiple times.

Harvest volume estimation

Summary statistics were provided for each region by MPI based on Emissions Trading Scheme Field Measurement Approach (ETS FMA) plots. For radiata pine these included:

- Mean site index
- Mean 300 index
- Mean final crop stocking for pruned and unpruned stands
- % 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 pruned/unpruned area.

These were input to the Radiata Pine Calculator (Maclaren & Knowles, 2005) to generate volume by market log grades. In Otago/Southland, radiata pine and Douglas fir blocks were differentiated. Average site index, 500 index and stocking were provided by MPI from the ETS FMA plots. The Douglas Fir Calculator was used to estimate volumes by log grade.

Markets

In each region, export and domestic market scenarios were evaluated. In Canterbury, a third combined scenario was also considered. Here, to be concise and also to make results more consistent and comparable we consider only the export scenario. It was assumed that all logs will be exported through the nearest export log port, with the exception of the chiplog grade which is transported to the nearest MDF plant (at Sefton in Canterbury and near Mataura in Otago/Southland).

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 (45 years for Douglas fir), 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 was included for the cost of log sales administration and marketing.

Log prices

For Canterbury, monthly AgriHQ log prices for each grade from April 2010 to March 2015, converted to real $December 2014, were used to provide context to the DWC results. For Otago/Southland, AgriHQ prices for radiata pine from April 2011 to March 2016, converted to real $December 2015, were used. For Douglas fir, prices provided by Port Blakely Ltd were used.

Classification of blocks

The rules adopted for classifying blocks:

- If the DWC is greater than the maximum log price (over the last five years) a block is *uneconomic* to be harvested
- If the DWC is greater than the average log price (over the last five 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 five 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 five years) a block is *economic* to be harvested.

Implications

The implications of our estimates of area and yields were evaluated by comparing with results of recent WAFs for Otago/Southland (MPI, 2014) and Canterbury (MPI, 2016c). WAF Scenario 2 was used to evaluate implications. Although it is a scenario which is unlikely to apply in practice (i.e. targeting non-declining yield from an estate that is far from normal), it allows for easy comparison of alternatives.

Results

Small-scale forest area

Mapped areas for the small-scale estate in each Canterbury TA are consistently less than NEFD estimates (Table 1). Overall, 39 864 ha were mapped, only 56% of the NEFD estimate. For Otago, more area was mapped than the NEFD for some TAs (including Dunedin City) and less area in other TAs (including Clutha). Overall the area mapped in Otago is 96% of the NEFD estimate (Table 2). For Southland, the mapped area is less area than the NEFD for all three TAs. The total Southland area mapped was 75% of the NEFD estimate (Table 3).

Table 1: Area of small-scale estate in each Canterbury TA. Mapped areas are compared with NEFD (2014). Mapped areas are total of net stocked area and area awaiting replanting. The % column represents the mapped area as a percentage of NEFD area

	NEFD (ha)	Mapped (ha)	%
Hurunui District	27,346	12,968	47
Waimakariri District	8,735	2,991	34
Christchurch City	8,524	3,922	46
Selwyn District	6,387	5,220	82
Ashburton District	1,892	1,313	69
Timaru District	7,466	6,090	82
Mackenzie District	3,471	3,122	90
Waimate District	6,740	4,237	63
	70,561	39,864	56

Table 2: Area of small-scale estate in each Otago TA. Mapped estimates are compared with NEFD (2015). Mapped areas are total of net stocked area and area awaiting replanting. The % column represents the mapped area as a percentage of NEFD area

	NEFD (ha)	Mapped (ha)	%
Waitaki District	9,349	9,466	101
Dunedin City	4,443	5,508	124
Queenstown-Lakes District	738	530	72
Central Otago	3,998	3,572	89
Clutha District	24,991	22,589	90
	43,519	41,665	96

Table 3: Area of small-scale estate in each Southland TA. Mapped estimates are compared with NEFD (2015). Mapped areas are total of net stocked area and area awaiting replanting. The % column represents the mapped area as a percentage of NEFD area

	NEFD (ha)	Mapped (ha)	%
Gore District	2,728	1,907	70
Southland District	29,249	21,818	75
Invercargill City	688	651	95
	32,665	24,376	75

Table 4: Total plantation area in each Canterbury TA. Mapped area for small-scale estate combined with NEFD estimates for large-scale estate are compared with LUCAS (2012) estimates. The % column represents the LUCAS area as a percentage of the combined mapped and NEFD areas

	Student/NEFD (ha)	LUCAS (ha)	%
Hurunui District	30,888	43,615	141
Waimakariri District	7,667	14,352	187
Christchurch City	5,765	9,715	169
Selwyn District	9,676	15,105	156
Ashburton District	2,940	7,236	246
Timaru District	10,972	15,974	146
Mackenzie District	4,534	11,650	257
Waimate District	9,177	12,276	134
	81,620	129,922	159

Table 5: Total plantation area in each Otago TA. Mapped area for small-scale estate combined with NEFD estimates for large-scale estate are compared with LUCAS (2012) estimates. The % column represents the LUCAS area as a percentage of the combined mapped and NEFD areas

	Mapped/NEFD (ha)	LUCAS (ha)	%
Waitaki District	20,270	22,730	112
Dunedin City	17,075	20,511	120
Queenstown-Lakes District	530	4,925	929
Central Otago	6,334	9,542	151
Clutha District	82,744	92,632	112
	126,953	150,340	118

Table 6: Total plantation area in each Southland TA. Mapped area for small-scale estate combined with NEFD estimates for large-scale estate are compared with LUCAS (2012) estimates. The % column represents the LUCAS area as a percentage of the combined mapped and NEFD areas

	Mapped/NEFD (ha)	LUCAS (ha)	%
Gore District	3,521	4,664	132
Southland District	71,181	89,191	125
Invercargill City	651	1,297	199
	75,353	95,152	126

LUCAS estimates (using LUCAS land use map 1990 2008 2012 version 11) for all TAs in Canterbury, Otago and Southland are consistently higher than those estimated in this study (Tables 4, 5 and 6). LUCAS plantation area is 59%, 18% and 26% higher in these regions, respectively.

Harvest volume

The average 300 Index of 22.7 m^3/ha/year for the ETS FMA plots in Canterbury falls in the indicative range for PSPs documented in the Radiata Pine Calculator (Table 7). However the value of 28.6 m^3/ha/year for Otago and 30.1 m^3/ha/year for Southland are relatively high for the PSP averages in these regions. Consequently, we used 90% of the overall average for Otago/Southland. The resulting estimates of volume are substantially higher than the WAF yield tables (Table 8). The latter were derived as an area-weighted regional average of the yield tables provided by large-scale owners that were subsequently calibrated against harvest intentions.

Delivered wood cost

There are marked differences in delivered wood cost (total harvesting, roading, transportation and marketing costs at age 28 years) between regions, both in terms of average (Table 9) and distribution (Figures 1 and 2). The key driver of the differences is transport costs, followed by harvesting costs and then roading costs. There are very few samples with DWC in excess of $100/t (Figures 1 and 2), although Queenstown-Lakes has 45% of samples with DWC in excess of this value and Gore has 15%.

Table 7: Productivity estimates from ETS FMA plots compared to Radiata Pine Calculator research PSP averages

	Productivity Index	ETS FMA	Research PSPs (ex-farm site)	Research PSPs (forest site)	Used by us
Canterbury	300 index (m^3/ha/year)	22.7	26.2	18.2	22.7
	Site index (m)	25.4	24.5	23.7	25.4
Otago	300 index (m^3/ha/year)	28.6	27.4	26.1	26.5
	Site Index (m)	26.5	26.4	25.4	26.0
Southland	300 index (m^3/ha/year)	30.1	25.7	26.5	26.5
	Site index (m)	25.4	25.5	25.6	26.0

Table 8: Estimated total recoverable volume (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)	
		ETS FMA	WAF	ETS FMA	WAF
Canterbury	Radiata pine	618	477	706	525
Otago/Southland	Radiata pine	672	521/518	775	509/534
	Douglas fir			917	611/657

Table 9: Average DWC at age 28 years for radiata pine samples in each TA together with component costs (harvesting, roading, transport and marketing)

	Samples	Harvesting	Roading	Transport	Marketing	DWC
		$/t	$/t	$/t	$/t	$/t
Hurunui District	100	30	10	30	5	75
Waimakariri District	30	24	7	18	5	53
Christchurch City	30	31	8	14	5	58
Selwyn District	40	28	8	21	5	61
Ashburton District	30	30	12	25	5	71
Timaru District	70	28	10	22	5	64
Mackenzie District	50	30	14	25	5	74
Waimate District	50	31	15	19	5	70
Canterbury	0	29	10	23	5	68
Waitaki District	119	24	9	30	5	68
Dunedin City	70	29	9	15	5	58
Queenstown-Lakes	11	23	8	58	5	94
Central Otago	30	27	10	39	5	81
Clutha District	86	29	8	28	5	69
Otago		26	9	30	5	69
Gore District	20	35	14	25	5	80
Southland District	84	26	6	30	5	68
Invercargill City	19	20	7	13	5	44
Southland		27	7	30	5	69

Log prices

Figure 3 provides context for the DWC distributions. It shows the average log price by month for Canterbury over the five-year period from April 2010 to March 2015 and for Otago/Southland from April 2011 to March 2016. The series are calculated using the log grade mix for a 28-year rotation for both pruned and unpruned regimes in the regions. The minimum, mean and maximum log prices over these periods are reported in Table 10. It is evident that Canterbury export log prices have generally been lower than those for Otago/Southland.

Table 10: Minimum, mean and maximum log price ($/tonne – at wharf/mill) for log mix produced at age 28 years for radiata pine and 45 years for Douglas fir. (Radiata pine log grade prices are monthly prices from AgriHQ prices, Douglas fir prices are from Port Blakely Ltd, Canterbury prices are real $December 2014, while Otago/Southland prices are real $December 2015)

	Canterbury radiata pine	Otago & Southland radiata pine	Otago & Southland Douglas fir
Minimum ($/tonne)	58	65	69
Mean ($/tonne)	81	90	101
Maximum ($/tonne)	108	113	119

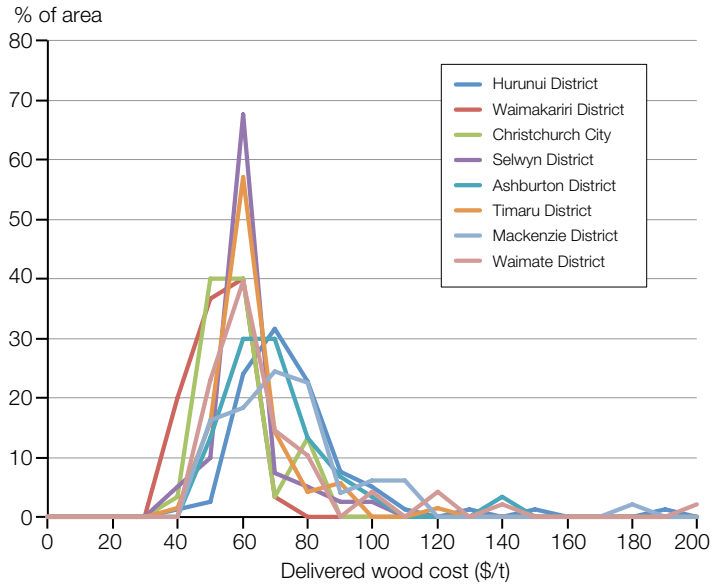

Figure 1: Distribution of total cost at harvest for each Canterbury TA with harvest at age 28 years

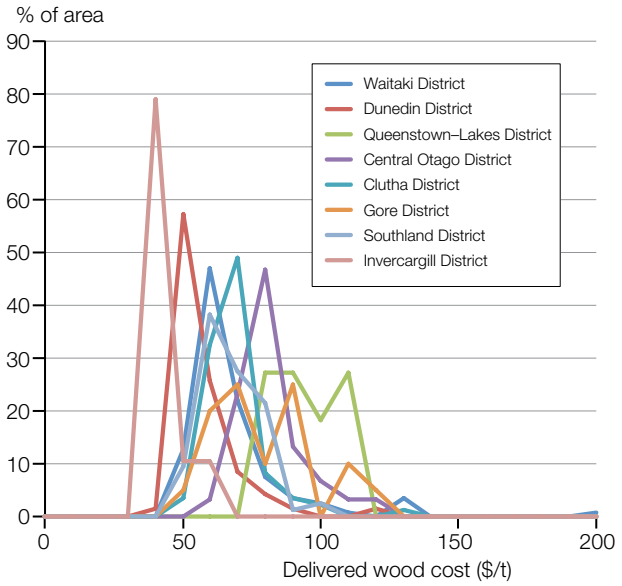

Figure 2: Distribution of total cost at harvest for each Otago/Southland TA with harvest at age 28 years

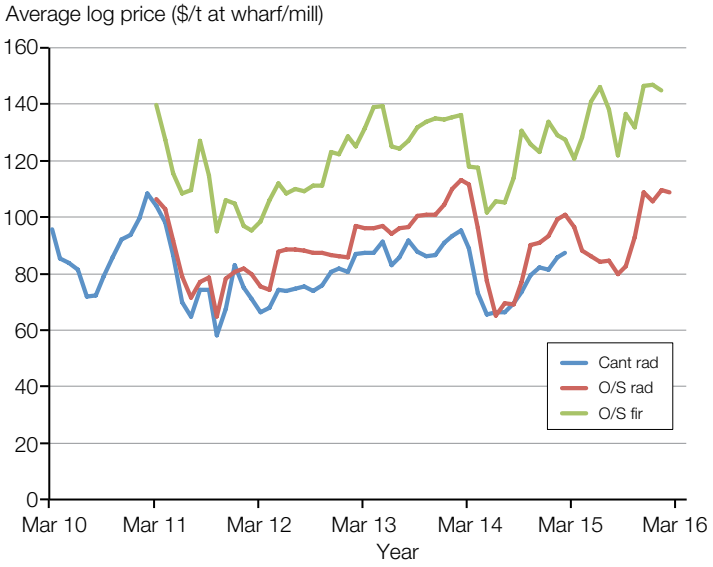

Figure 3: Weighted average log price ($/tonne at wharf/mill) for log mix produced at age 28 years for radiata pine and 45 years for Douglas fir. Radiata pine log grade prices are monthly prices from AgriHQ prices. Douglas fir prices are from Port Blakely Ltd. Canterbury prices are real $December 2014, while Otago/Southland prices are real $December 2015

Delivered wood cost at age 28 relative to log prices

From 0% to 8% of the samples in each region are uneconomic to harvest (Table 11). Weighted averages for the TAs in each region have 2.8%, 2.2% and 0.4% in the uneconomic category and 10%, 6% and 5% in the marginal category for Canterbury, Otago and Southland, respectively. For Douglas fir, there is no area in the uneconomic and marginal categories (Table 12).

Implications

Otago/Southland

Using mapped area rather than the WAF area gives a small increase in the volume forecast from the small-scale estate in Otago under WAF Scenario 2 and a decrease for Southland (Figures 4 and 5). The mapped area was only 96% of the NEFD area in Otago and 75% in Southland. The WAF used the NEFD area as a starting point but made some deductions, principally a reduction of 15% as 'small-scale owners generally report on a gross area basis rather than net stocked areas' (MPI, 2014). Consequently, the WAF area was lower than the mapped area for Otago but higher for Southland.

The major difference occurs when our yields (based on ETS FMA plots) are used rather than WAF yields. The WAF yield tables for the small-scale estate in Otago/Southland were the same as those developed for large-scale owners.

One task of the Management Case Study in 2016, conducted in Otago/Southland, was to address the question: 'Is there sufficient wood for a 600,000 tonne/year (log input) sawmill producing appearance lumber from large radiata pine logs?' The answer to this question is conditional:

- Yes – if the yields based on FMA plot averages are correct.
- No – if the WAF yields are correct.

Table 11: DWC of radiata pine samples at age 28 relative to minimum, mean and maximum log prices over a five-year period (numbers are the percentage of samples in each region that have DWC in each class)

	Samples	Economic	Probably	Marginal	Uneconomic	Total
		%	%	%	%	%
Hurunui District	100	9	72	15	4	100
Waimakariri District	30	70	30	0	0	100
Christchurch City	30	63	33	3	0	100
Selwyn District	40	28	68	5	0	100
Ashburton District	30	23	57	17	3	100
Timaru District	70	23	67	9	1	100
Mackenzie District	50	20	56	20	4	100
Waimate District	50	36	50	6	8	100
Canterbury		28	60	10	3	100
Waitaki District	119	54	37	4	5	100
Dunedin City	70	79	19	1	1	100
Queenstown-Lakes District	11	0	36	60	4	100
Central Otago District	30	2	77	17	3	100
Clutha District	86	26	69	4	1	100
Otago		37	55	6	2	100
Gore District	20	21	50	24	5	100
Southland District	84	41	55	4	0	100
Invercargill City	19	99	1	0	0	100
Southland		41	53	5	0	100

Table 12: DWC of Douglas fir samples at age 28 relative to minimum, mean and maximum log prices over a five-year period (numbers are the percentage of samples in each region that have DWC in each class)

	Samples	Economic	Probably	Marginal	Uneconomic	Total
		%	%	%	%	%
Waitaki District	1	100	0	0	0	100
Queenstown-Lakes District	9	78	22	0	0	100
Clutha District	13	100	0	0	0	100
Southland District	15	100	0	0	0	100

Canterbury

Our findings were used in the Canterbury WAF: 'This resulted in the modelled small-scale owner resource being 45% less than that shown in the NEFD' (MPI, 2016c). A decision was also made that, 'unlike other regions, the small-scale owner yield tables would not share the same yield tables as the calibrated large-scale owners'. Instead, the small-scale owner yields were based on yield tables from large-scale owner forests located on the more productive foothills rather than the less productive plains (MPI, 2016c). The impact of basing WAF yield tables on more productive sites is evident in Figure 6. Also clear is the impact of using yields based on FMA plots rather than WAF yields.

Discussion

What is the area of small-scale estate in each TA within these regions?

It is evident that the NEFD does not provide an accurate estimate of the small-scale estate in each TA. The mapped area differs from the NEFD area by at least 10% in 13 of the 16 TAs in Canterbury, Otago and Southland. The difference exceeds 20% in nine TAs. The combined mapped area was only 72% of the NEFD area. Although the aggregate Otago area was most accurate (mapped areas 96% of NEFD area), there were large differences in the total area for Southland (75%) and Canterbury (56%).

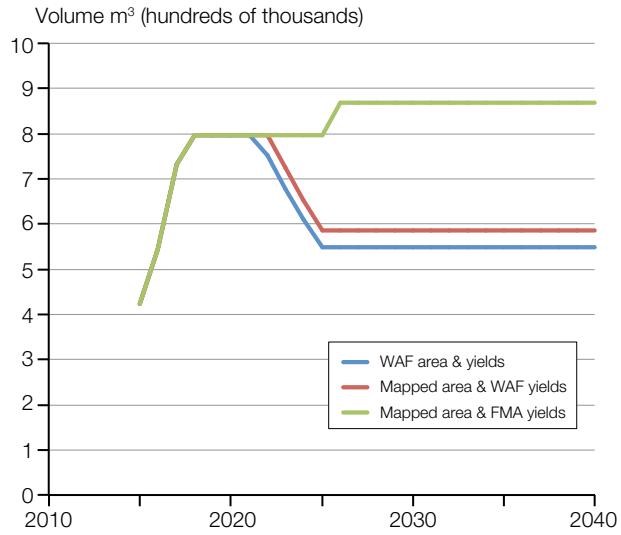

Figure 4: Forecast of total recoverable volume for Otago small-scale estate using: (i) WAF area and yields; (ii) mapped area and WAF yields; and (iii) mapped area and yields based on ETS FMA plot averages

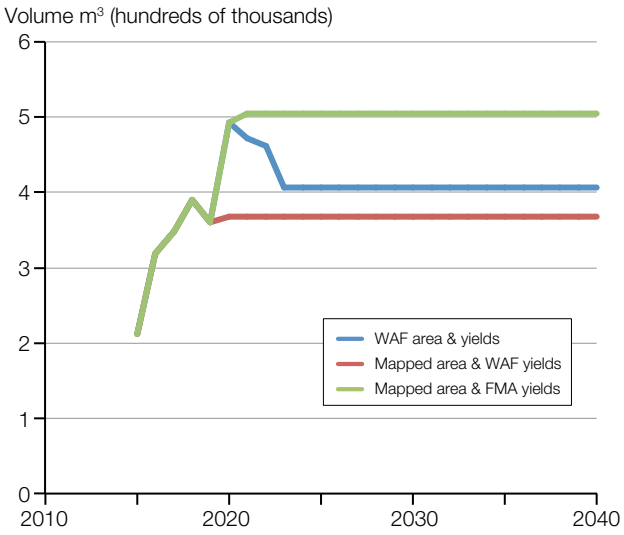

Figure 5: Forecast of total recoverable volume for Southland small-scale estate using: (i) WAF area and yields; (ii) mapped area and WAF yields; and (iii) mapped area and yields based on ETS FMA plot averages

It is not surprising that the LUCAS plantation area is greater than our estimate. LUCAS areas are consistently higher than NEFD areas because of the approach used – gross, rather than net, areas are estimated using satellite imagery. For example, the LUCAS estimate of planted forest in 2015 is 2,076,528 ha (MfE, 2017), which is 17% higher than the 2015 NEFD area of 1,771,618 ha, including 53,903 ha of area awaiting replanting. LUCAS estimates for all regions differ from our estimates by more than 17%. Otago and Southland differences are not much greater than 17%, being 18% and 26%, respectively. However, the 59% difference for Canterbury was much higher than the national average difference. Comparison of plantation area in the LUCAS LUM (land-use map) with our mapped area confirmed that the LUCAS definition of boundaries for specific stands were often approximations. However, the comparison also revealed misclassification of area. In some cases, plantations (pre-1990 planted forest or post-1989 forest) had been classified as some other land use. More commonly areas of native forest, including shrubland, or grassland had been incorrectly classified as plantation.

The LUCAS system estimates of carbon are based on permanent sample plots located on a national grid of 8 km x 8 km for pre-1990 planted forest and 4 km x 4 km for post-1989 forest. A gross to net adjustment is made based on the proportion of grid points in the plantation land use classes that have planted forest. While there is internal consistency in LUCAS, a consequence of the methodology adopted is that the 2012 LUM does not provide an accurate map of New Zealand plantations.

It should be noted that these discrepancies are not accounted for by the minimum mapping area of 1 ha that we adopted. In the 2014 Management Case Study students undertook an exercise in which they mapped out all small-scale forest regardless of size. They found that the area of stands that were less than 1 ha was only 2.4% of the area of small-scale estate stands that were over 1 ha in area.

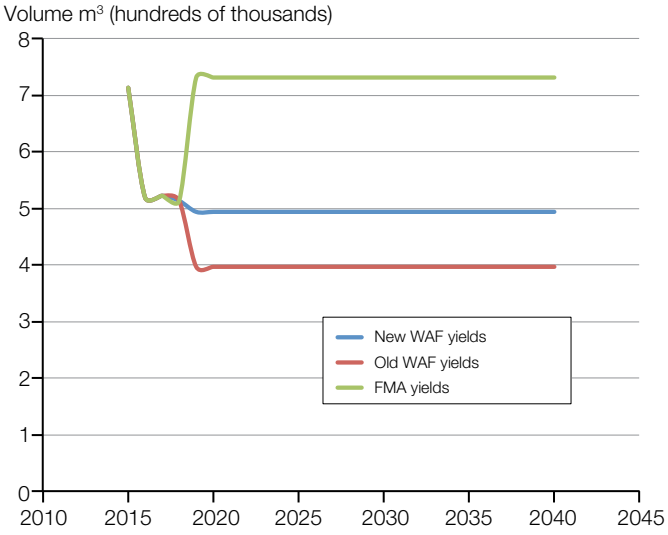

Figure 6: Forecast of total recoverable volume for Canterbury small-scale estate using: (i) WAF yields based on foothill sites; (ii) old WAF yields based on plains and foothill sites; and (iii) yields based on ETS FMA plot averages

What percentage of the small-scale estate is economic to harvest?

Only a small proportion of the small-scale estate is uneconomic to harvest. On average, only 3% of blocks are classified as uneconomic to harvest at age 28 years in Canterbury, 2% in Otago and less than 1% in Southland. A further 10%, 6% and 5%, respectively, are classified as marginal. As noted by Manley el al. (2015):

> *… 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.*

Only the log export option was evaluated in this study. If domestic processing does expand there will be a reduction in DWC if the additional capacity is located close to forests. The proportions reported here would only change, however, if domestic processing resulted in increases in the net revenue to the forest grower.

The VCM estimates are of costs associated with professional harvest operations. Some of the stands deemed uneconomic to harvest may in fact be harvested at costs lower than those estimated by the VCM. Conversely, just because prices are sufficient to cover DWC does not mean that a forest grower will harvest a stand. In most cases they will be seeking a profit from harvest to recoup costs incurred in establishment, tending and overheads.

The results are at the high end of the range reported by Manley et al. (2015) for North Island regions. As was the case for the North Island study, a large proportion (here over 50%) of area is in the probably category and sensitive to log prices staying above average levels.

What is the potential future yield from the small-scale estate?

The answer to this is that we do not know. The WAF yield tables are based on yield tables for large-scale owners calibrated by harvest intentions. The question is how relevant they are for the small-scale estate. Certainly the ETS FMA plots indicate higher levels of productivity for this segment of the small-scale estate (i.e. forest growers with over 100 ha participating in the ETS). Our estimates, based on a model without calibration to actual harvested volumes, are likely to be too high. In addition, there is a question about how representative they are of the total small-scale estate.

Conclusions

The small-scale estate is an increasingly important component of the New Zealand estate yet we know surprisingly little about it:

- We do not accurately know the total area of the small-scale estate, and by extension, the total New Zealand plantation area
- We do not know where it is located
- We do not accurately know the yields it will generate.

It is evident that the NEFD estimates of area are not accurate for the small-scale estate. It is also apparent that the LUCAS LUM does not provide an accurate map of New Zealand plantations, both because it estimates gross area rather than net area and also because of misclassification of land use.

Results of the Management Case Studies reported here have been presented to the NEFD Steering Committee over the last two years. This has raised sufficient concern about NEFD accuracy to galvanise plans to develop a spatial database of the total New Zealand plantation estate. It is proposed that remote sensing techniques be used, in conjunction with existing databases, to address the three questions raised in this study.

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Bruce Manley is Head of School and Professor of Forest Management at the School of Forestry at the University of Canterbury in Christchurch. Justin Morgenroth is Senior Lecturer in Geospatial Technologies and Rien Visser is Associate Professor of Forest Engineering. Corresponding author: bruce.manley@canterbury.ac.nz.