South Otago Wood Residue Supply Assessment.

A report prepared for Wood Energy South, Venture Southland, and the Energy Efficiency Conservation Authority.

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Executive Summary

An opportunity exists for industrial energy users in South Otago to obtain their energy requirements from locally sourced renewable wood fuels. The findings of this report demonstrate there are good opportunities for industrial users of energy who are located in Balclutha, Milton or Clydevale, to develop long-term relationships with local forest owners who are seeking to develop additional markets for their lower-value log grades.

The corporate forest estate within the project area is significant and stable, providing the backbone of the wider Otago forestry industry, and providing reliable woodflow supply to the downstream wood processing industry. Woodflows from across Otago and Southland are planned to increase significantly in forthcoming years. Already a considerable industry in the southern regions, forestry is soon to become even larger and significant as a contributor to the regional economy. Over the next decade there will be a considerable increase in the expected harvesting across these regions. Currently there is an estimated 800,000 tonne of logs annually harvested in the South Otago areas, expected to rise to 1,100,000 tonne by 2019, and 1,300,000 tonne by 2025. This steadily increasing harvest volume provides increasing opportunities for users of wood energy, which will be sustained into the future.

Of the existing 2014-15 South Otago total harvest volume an estimated 225,000 tonne of lower-value log products will be produced from these forests. Of this, an estimated 65,000 tonne is commited to the Dongwha-owned Medium Density Fibreboard (MDF) processing plant in Mataura. An additional estimated 20,000 tonne of billet wood is sold to either existing energy markets, or to the MDF plant. The remaining 105,000 tonne of lower-value logs are sold to export markets, via Port Chalmers wharf. It is estimated that an additional 35,000 tonne of billet-wood type logs are left unrecovered in the forests, remaining there due to the lack of profitable markets for these logs.

The graph in Figure 1 shows the expected increase in lower-value residues from within the South Otago area, over time. The portion in blue is commited to the MDF plant, the portion in red is the expected volume which will be destined for either an alternative market (such as wood energy) or for export pulp markets, and the portion in green is the expected volume of billet wood that could be recovered and sold to the energy market.

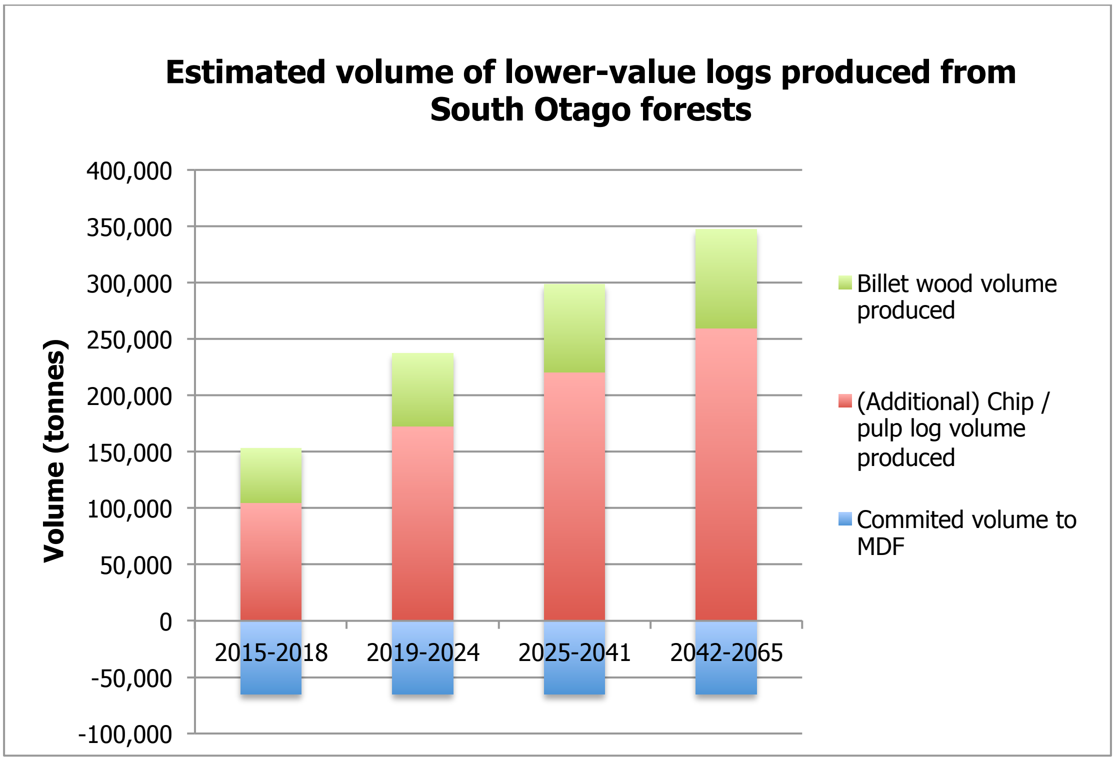

Figure 1 Estimated volume of lower-value logs produced from South Otago forests.

As the graph in Figure 1 shows, industrial-scale energy users have strong potential to secure some of the export-oriented pulp log supply or to provide an alternative domestic option to the MDF plant for chip logs. Corporate forest owners within this area value the reliability and stability of the Dongwha MDF plant and are commited to ensuring continual input into that plant. However, the expanding Otago-Southland regional resource means that the MDF plant will not suffer from a shortage of supply and will likely start to favour more proximate suppliers of chip log than those situated in South Otago. The MDF plant is not expected to increase its log requirements beyond that already demanded and, given the signficant increase in forecast harvest volumes, there will be a significant increase in the availability of low-value residues over coming years.

The export pulp market, though at times bouyant and providing good returns for forest owners, is a highly fluctuating market whose long-term averages are only slightly higher than the domestic chip price. It is important to note, too, that the export pulp grade specification has higher quality requirements than the domestic chip log grade. As a result, there is always a proportion of the total volume of forest harvested which will need end-markets that are less discerning of quality than that posed by the export markets.

The existing availability of 100,000 tonnes of lower-value forest residues provides 928,000 GJ of energy (gross calorific value (GCV)), amounting to 715,000 GJ (net calorific value (NCV)). The difference between the gross calorific value and net calorific value is the energy required to evaporate the moisture content of the wood fuel during the burning process. In less than a decade this supply will more than double. In addition, there are signficant volumes of wood chip being produced from sawmills. Currently all production of wood chip is under contract to either the Dongwha MDF plant at Mataura, or to a plethora of dairy farms in the region. There is also existing use of the sawmill chips by industrial users within the area. However, anecdoctal evidence suggests that local wood processing will increase markedly in the immediate future, providing opportunties for large scale energy users to purchase wet chip directly from sawmills. Unfortunately this opportunity is not available at this point in time.

Four forest areas, shown in the map in Figure 2 below, have been assessed for their potential to supply lower-value residue to local energy users in Balclutha and Clydevale. Each of these forest area's has a mixed ownership structure of large corporate forest owners, and smaller private forest owners. The corporate forest owners commonly own forests within at least two of the forest areas, managing them as one, and harvesting across a number of sites at any one time. The development of an alternative domestic market for low-value residues would be positively greeted by forest owners in the South Otago area, especially by those owners which are more distant from the MDF plant at Mataura. Price analysis shows that forest owners in the Waipori, Beaumont and Coastal Otago forests will benefit from local demand for lower-value residue.

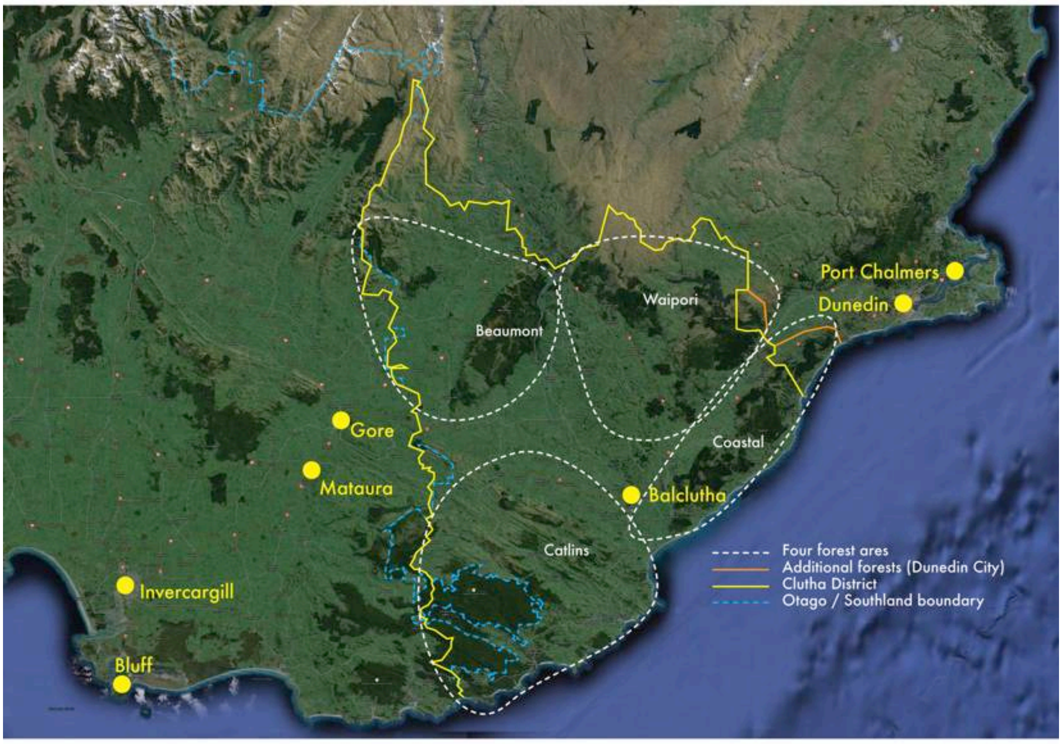

Figure 2 Forest areas within the project assessment area

The most feasible way of utilising the log residue for energy generation is for large-scale energy users to purchase log residue directly from the forest owners, to store logs at a central processing yard at the same site where the energy will be consumed, and to process these logs as and when needed. Maintaining a buffer supply on site, of both processed chip and of log residue, will be an important component of the supply chain. Use of the traditional log and load system is recommended as the best supply chain for log residue recovery from the forests. This wood chip supply pathway is consistent with current harvesting systems, with little deviation from current practice for harvesting crews and therefore will keep the cost of production as low as possible.

Medium-term supply agreements should be negotiated with forest owners, ensuring stability of pricing for all parties, and consistent supply of product. At $45 / tonne (or $4.85 / GJ (GCV), or $6.30 / GJ (NCV) there is likely to be some interest from forest owners who are proximate to the end user. However, at this price a new wood energy market would not compete with a buoyant, or even average, export pulp market. During this assessment work it has been strongly expressed by the forestry industry that for supply relationships to be cemented in goodwill and longevity, a base price of $50 / tonne (or $5.40 / GJ (GCV) or $7.00 / GJ (NCV)) is more realistic. Additional processing costs, borne by the purchaser of the logs, is estimated to be between $20 and $25 / tonne, providing a total estimated energy cost of $8 / GJ (GCV) or $10.50 / GJ (NCV). Both the end user and the forest owner will benefit from being proximate to one another, and being able to reduce the proportional impact of cartage cost. Negiotiated commercial agreements will serve to refine these costs, and to reduce any excessive margins that may exist at the outset. These costs do not include the capital costs of chipping and handling infrastructure.

Contents

1.0 Background

Wood Energy South has been set up to promote a shift in Southland to a cleaner, more sustainable fuel, improving air quality, and helping to support a new industry around the use of waste wood as an energy source. The project is being funded over three years (2014-2017) and aims to lower energy-related carbon emissions in Southland, improve air quality and demonstrate the cost and life cycle benefits of wood-chip and wood-pellet fuelled boilers utilising local waste wood. It will also provide local employment capacity building and business opportunities.

The Wood Energy South is primarily focused on overcoming market barriers to establish a regional cluster of wood energy end-use in commercial and industrial applications. Despite a proven economic case and technological maturity, renewable energy for heat faces several barriers including long technology 'lock-in' due to long asset life, perceived security-of-supply risks and a lack of price disclosure.

Though primarily focussed on Southland, the Wood Energy South project has recently advocated that the South Otago area also be included in its scope. This is because it has been recognised that there are some large commercial users of energy who would potentially be strong candidates to use wood energy, due to their existing reliance on more expensive and less sustainable energy resources.

This report was commissioned so as to provide certainty to candidate industrial wood energy users within South Otago about the ongoing availability of wood residue as an energy source. This assessment is focussed on South Otago, which is predominately the Clutha District but includes an adjacent area of Coastal Otago immediately north, within Dunedin City's territorial boundary.

This assessment seeks to complete the following objectives:

1. Evaluate the available woody biomass resources that are available in the South Otago area.
2. Highlight the challenges and constraints to enabling a supply network, to identify solutions to overcome likely constraints, to identify the most profitable and effective supply chains, and to provide clear strategy to enable the sustainable delivery of wood fuel to potential industry users.
3. Evaluate forest owner's opinions and perceptions of a potential wood energy market for residues, and what is necessary to enable its success.
4. Investigate and assess the feasibility of supply chains for the recovery, transport, production, storage and distribution of green wood chip.

2.0 The Forest Growing Industry

This resource assessment is focussing on South Otago, an area that is predominately the Clutha District and an adjacent area of Coastal Otago immediately north, within Dunedin City's territorial boundary. The Clutha District forms the majority of the South Otago area, as shown in the map below.

The South Otago area is also well known for its extensive forest estate, including both corporate and small forests. The collective contribution of small forest owners is significant, reflecting the enthusiasm and knowledge of small forest owners in this area.

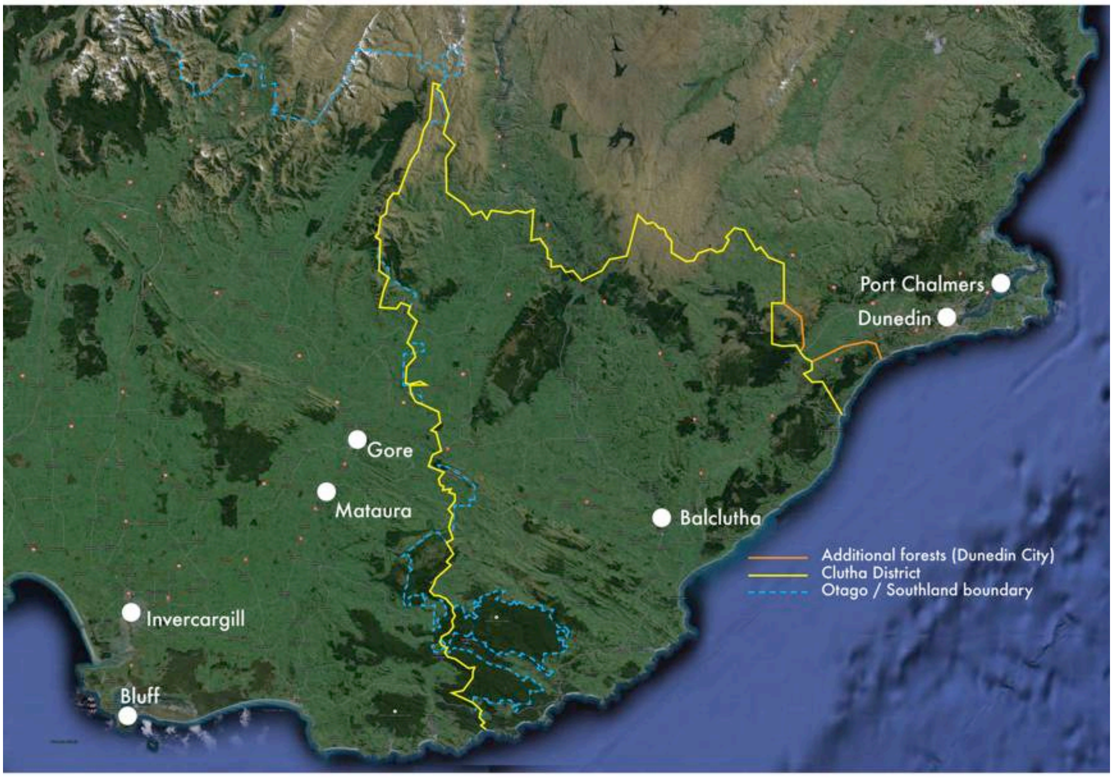

Figure 3 Project Assessment Area.

2.1 Forest ownership within Clutha District.

Using data generated from the Clutha District Council (CDC) ratings database, and cross-referenced against confidential information provided by corporate forest owners for the purposes of this study, the following graph was produced. This shows the proportion of forest area (in hectares) within each size class.

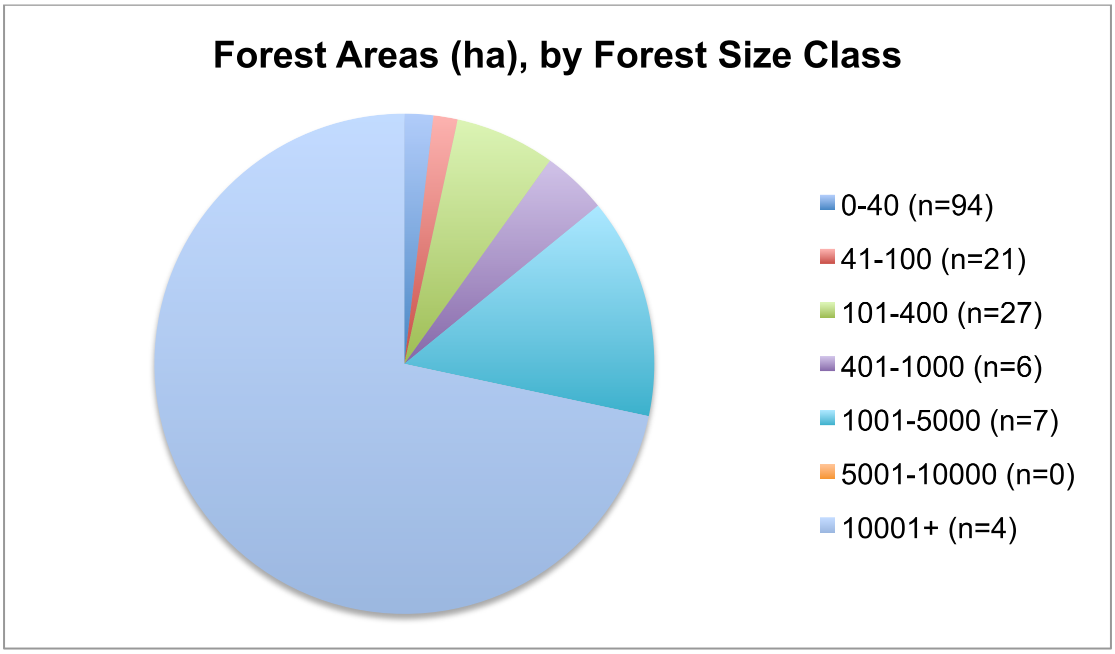

Figure 4: Number of forest owners, by forest size class, as a proportion of overall forest estate

The graph (Figure 4) above shows that there are four forest owners with holdings greater than 10,000 hectares, collectively accounting for over 58,000 hectares of the 82,000 hectares of forestry (70%) within the CDC boundaries. There are seven forest owners with forests between 1,000 and 5,000 hectares, collectively accounting for nearly 12,000 hectares of forestry (15%) within the CDC boundaries. The remaining 12,000 hectares (15%) of forestry land is owned by smaller forest owners with less than 1,000-hectare holdings. It is estimated there are 148 separate forest owners with less than 1,000 hectares apiece in the CDC boundaries.

2.2 The Large Forest Owner Estate

As described above, the corporate forest within the project area is significant, providing the backbone of the Otago forestry industry, and providing reliable woodflow supply to the downstream processing industry.

The corporate forest owners all have permanent harvesting contractors working within their forests, year round. At key times – such as buoyant log markets – additional, temporary, harvesting contractors, sometimes supplement their permanent forest harvesting capability. Much of the large corporate forestry estate is into its second rotation of forest crops, and as such has well-developed infrastructure. In contrast, the smaller forests typically do not have established internal roading and are instead harvested in a piecemeal manner that incorporates forest roading as the harvesting activity progresses.

The major forest owners are described in Appendix 1.0.

3.0 Processing, Infrastructure, and Markets

3.1 Forest Harvesting and Infrastructure

The considerable forestry estate in South Otago is characterised by good forest infrastructure, and a medium-scaled forest processing industry. The Panpac sawmill at Milburn is expected to be the largest log processor within the coastal Otago area, forecast to processing 100-120,000 tonnes of logs per annum into sawn timber. Gorton Timber Company Ltd (Milton), Stuarts sawmill (Tapanui) and Hollows sawmill (Balclutha) each process between 20,000 and 50,000 tonnes of sawlogs per annum.

The medium density fibreboard (MDF) factory at Mataura is the other major processing facility, 75 kilometres from Balclutha. Owned by Dongwha New Zealand, this processing facility has typically consumed between 350,000 tonnes and 390,000 tonnes of chip volume to produce the MDF product. Approximately two-thirds of this consumption is derived from logs, and the remainder as chip residue from sawmills.

3.2 Port Infrastructure

Balclutha, as the largest town in the Clutha District, is 92 kilometres from Port Chalmers in Dunedin and 153 kilometres from the Port at Bluff, in Invercargill. The presence of these two significant export outlets is an essential component of the forestry industry in Otago and Southland.

Export volumes have increased significantly in recent times, as shown in the table below.

Table 1 Log export volumes through Port Chalmers and Bluff.

Year end March	Bluff (m3)	Port Chalmers (m3)
2006	74,183	273,099
2007	91,816	260,115
2008	103,435	236,518
2009	101,371	363,393
2010	269,488	577,797
2011	301,357	639,154
2012	208,938	651,197

2013	314,743	770,435
2014	395,503	810,284

3.4 Transport

Both Invercargill to the south, and Dunedin to the north, are well serviced by trucking transport. Sending logs and timber to Dunedin, or close to Dunedin, does provide greater ability to 'backload' freight, contributing to more efficient freight logistics and less cost per unit.

4.0 Assessment of the project area's forest biomass resource.

The primary objective of this study is to understand the security of supply of log residues, into the future. As such, considerable attention has been paid to assessing the forest biomass resource within the project area. In producing this report we have collected information from a variety of sources, including national databases, council databases, project-specific mapping of local resources, and from targeted interviews with corporate forest managers.

The assessment of the forest biomass resource is divided into two parts:

1) An assessment of the forest estate across the Otago Region, and;
2) An assessment of the forest estate across the South Otago project area, as per territorial authority boundaries.

Analysis of the Otago regional forestry estate and the South Otago forestry estate is provided in Appendix 2.0.

5.0 Wood Availability Forecasts for Otago and the South Otago Area

5.1 Background

In 2014, the forestry consultants Indufor Asia Pacific Limited (Indufor) completed wood availability forecasts for the Ministry for Primary Industries (MPI). The regionally focussed forecasts were developed to inform local industry, councils, infrastructure and service providers to assist in their planning needs. These forecasts for Otago / Southland (2014) have been used as the basis for discussion of the availability of wood at a regional level, and as such, the potential availability of woody biomass.

Indufor prepared four production scenarios for radiata pine potential wood availability, one for Douglas-fir availability, and one scenario that combined radiata pine and Douglas fir. The scenarios demonstrate possible scenarios for harvesting the Otago-Southland forest resource in the period 2014-2050. The scenarios are based on the available resource in each region, alongside a series of forecasting assumptions (Indufor, 2014).

The forecasts are generated from the harvesting intentions of the region's large-scale forest owners, being those with greater than 1000 hectares. The scenarios were then used as the basis for consultation with forest managers and consultants, ensuring they provided realistic representation of the industry. A high degree of confidence is placed in the harvest intentions of the large forest owners, due to their consistent harvest programmes.

The intentions of the small forest owners are less obvious, with the timing of harvest being influenced by a range of factors. These factors include: individual forest owner objectives, forest age, log prices, current demand by proximate wood processors, and perceptions about future log prices (Indufor, 2014).

5.2 Otago Wood flow availability forecasts

In figure Figure 5 below, the large-scale owners resource is shown as the "base" volume, in blue. The fluctuations in the total annual forecast volumes reflect the variations in the areas of the small-scale owners estate, and the assumption that all radiata pine is harvested at age 28. This base scenario is incorporated simply to provide an overview of the fluctuations in the forest estate.

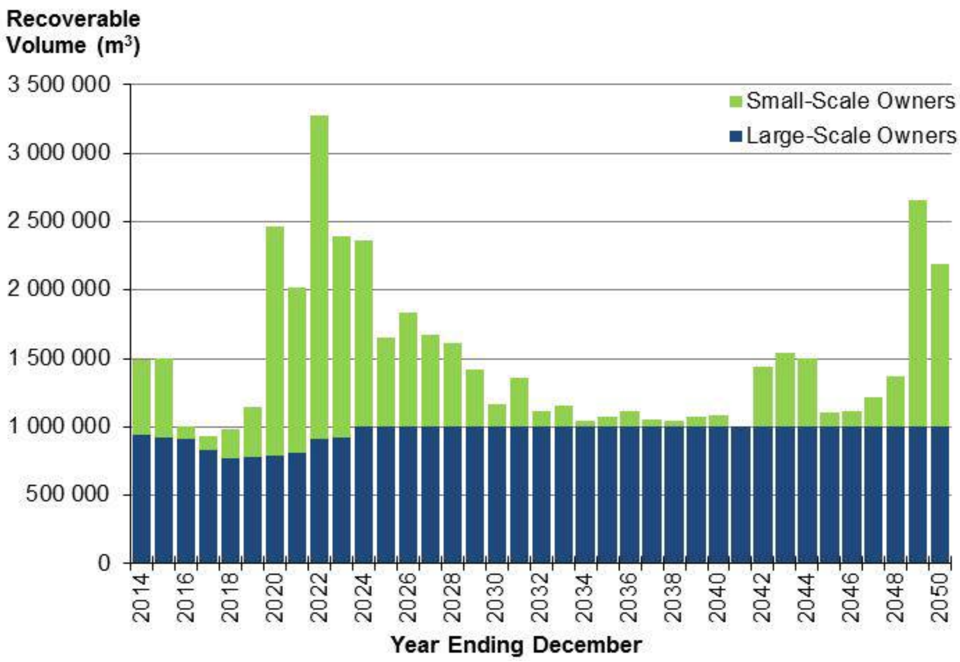

Figure 5 Otago Region's Radiata Pine availability, under scenario 1, harvest occurring at age 28 (Indufor, 2014: 10).

The large increase in harvest volume after 2019 reflects the maturing of the small-scale owners' estate. For example, the increase in 2020 is a consequence of the 3,240 ha planted by small-scale owners in 1992 being harvested at age 28 years.

Fluctuations in harvest volumes of the magnitude shown the figure above would be impractical due to operational constraints (for example: availability of harvest machinery, harvesting crews and transport operators) and market absorption constraints (for example: limited domestic wood processing capacity, levels of export demand), (Indufor, 2014:10).

5.3 Douglas-fir & Radiata Pine Combined, across Otago.

Feedback from major forest owners in the region suggested Douglas fir was often used to fill gaps in the radiata harvest profile. In the figure below, a non-declining yield constraint is modelled at a combined level for the radiata and Douglas-fir estate. The results suggest that from 2023 a sustainable harvest of 1.90 million cubic metres per year is possible from the combined radiata and Douglas fir estates, with the Douglas-fir harvest becoming more significant from 2020 onwards. It was therefore recommended that radiata pine and Douglas fir be modelled together. The radiata pine and Douglas fir large-owner estate was harvested as per their harvest intentions for the first 10 years (Indufor, 2014:17).

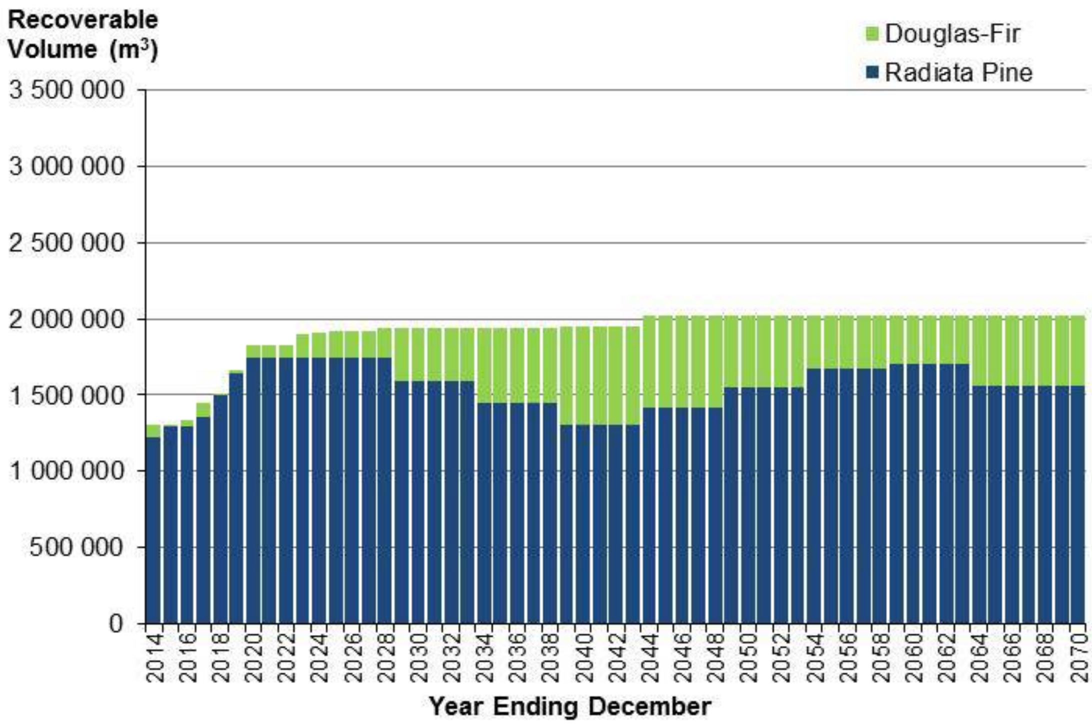

Figure 6 Otago Region's Combined Availability of Douglas-fir and Radiata Pine, including volumes from Douglas fir production thinnings (Indufor, 2014:17).

One of the impacts of combining the radiata pine and Douglas-fir harvests is that the Douglas-fir harvest tends to be delayed to boost the total volumes once the radiata pine planted during the 1990s has been harvested. However, an analysis compared the rotation ages from the Douglas-fir only scenario, and the combined Douglas fir and radiata pine scenario. It was found that there is little difference in terms of harvest age between the two scenarios, meaning that the Douglas fir can be typically harvested close to target rotation age (ibid, 2014:17).

Most of the potential increase in wood availability from 2015 onwards will come from the region's small-scale forest owners who established forests during the 1990s.

Market conditions and logistical constraints will determine the actual rate of harvest increase, and to what level is reached.

It should also be noted that additional volume will be available from the short rotation eucalyptus resource and other minor species in Otago, which are not included in these wood availability forecasts (ibid, 2014:35).

6.0 Wood availability forecasts for the project area.

Forest Managers from each of the large corporate forests participated in this assessment by taking part in one-on-one interviews. The interviews aimed to confirm the extent of forecast harvesting activity within the project area, to confirm forest areas, and to evaluate opinions about the current use of wood residue as well as the future opportunities for wood energy.

Data was collected from each of the forest managers and then analysed so as to evaluate future estimated wood flows. It is important to note that this data only includes the large forest owners. These large forest owners collectively manage an estimated 72% of the 84,400-hectare forest area that is the subject of this report. The forest areas that contribute to this collective forest estate have been named as "Catlins", "Beaumont", "Coastal Otago" and "Waipori". These areas are shown in the map below.

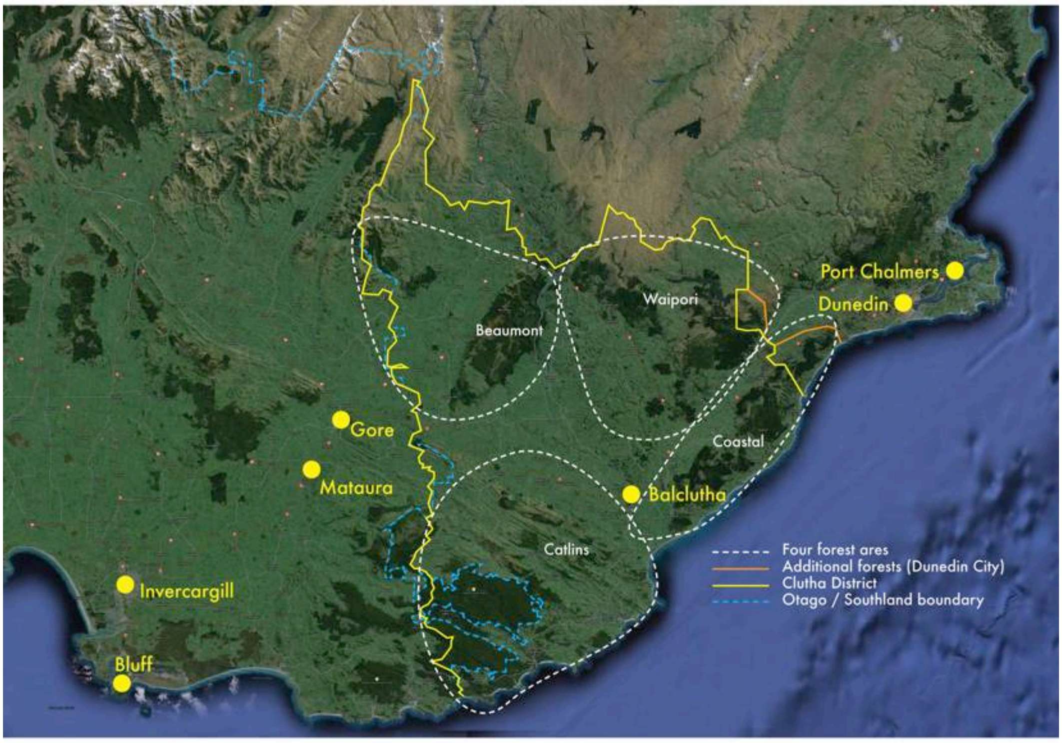

Figure 7 Forest areas within the assessment area

The majority of the corporate forests within the forest areas of Beaumont, Waipori and Coastal Otago have been established for some decades, and have well-established forest infrastructure that has been developed over time. By combining the expected harvesting intentions of each corporate estate, each of these forest areas provides a fairly consistent annual yield. Within the forest areas there exists a small number of corporate forest owners, complemented by smaller forest owners. Most corporate forest owners have their estate scattered over two-three forest areas, and manage that broader area as their forest estate.

The Catlins forest area is more recent, and much of it is first rotation forest. It is also considerably more "lumpy" than the more northern forests, reflective of the large single age-class plantings that have occurred.

Figure 8 below shows (in blue) the total annual area that is available for harvest, under a fixed rotation model (28 years for radiata pine and 45 years for Douglas fir). As discussed in the assessment of the availability of wood from the Otago region, such age class modelling does not necessarily translate into expected harvest intentions. Instead, forest managers aim to create steady and sustained harvest yields, providing certainty of capacity for themselves, the log markets, infrastructure requirements, and workforce.

As such, the red portion of the graph is a non-declining yield, showing the various increases in sustained yield harvest volumes as time passes. It shows an increase in available hectares for harvesting in 2019 (to 1295 hectares / annum), and then again in 2025 (to 1558 hectares / annum), and then again in 2042 (to 1769 hectares / annum).

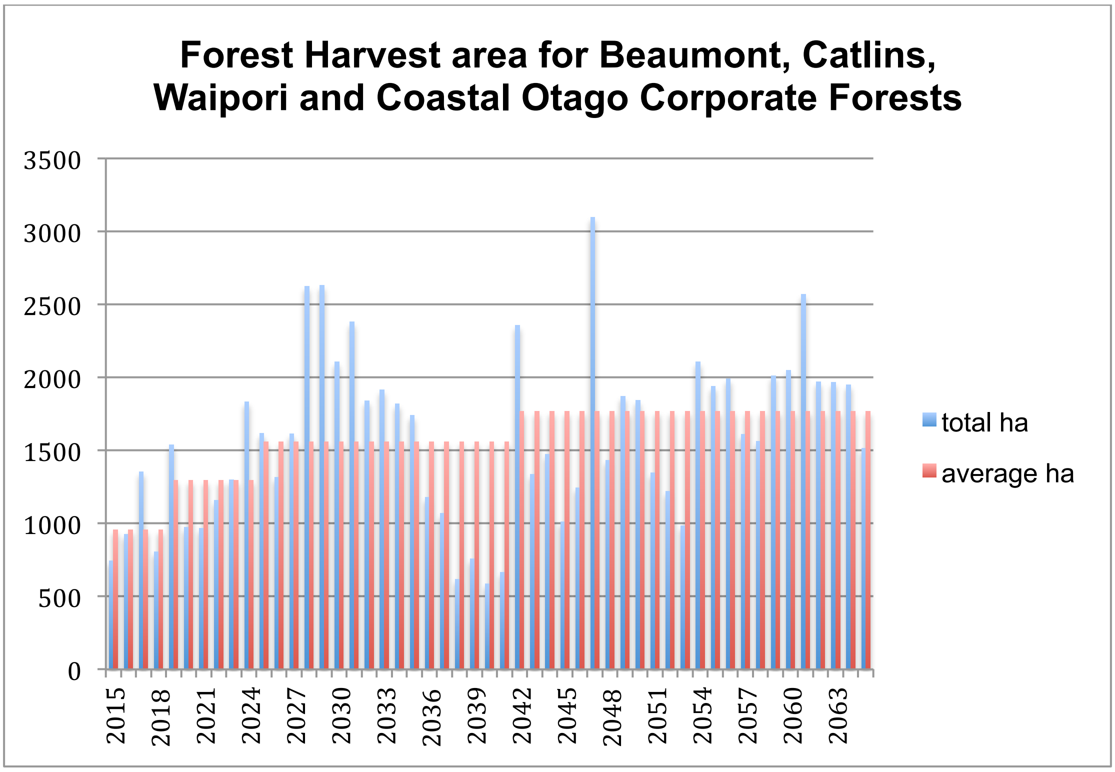

Figure 8 Forest harvest areas for Beaumont, Catlins, Waipori and Coastal Otago Corporate forests.

7.0 Availability of forest biomass resource for energy

Understanding what resource is available as a viable and consistent supply of raw resource to enable the production of wood energy is a primary objective of this project. The raw resource could arise from two main sources, namely:

1. Use of existing local low-value log products that are currently marketed and sold into alternative markets;
2. Use of existing by-product and arising's from sawmills;
3. Capturing wood residue that is not currently sold from the forest site.

7.1 Use of existing local low-value log products

Domestic chip log market

Large forest owners typically supply a number of markets with their lower-value log products. Chip logs, with a minimum length of 3.0 metres and a Small End Diameter

(SED) are sold either as export pulp logs, as chip for the export market, or as chip logs for the Mataura-based Dongwha medium density fibreboard (MDF) plant.

Prices paid for the chip logs can differ between clients, often depending on the distance from forest to MDF plant. There has historically been an additional premium paid for chip logs that are further afield, so as to offset the additional cartage cost. As at the time of this assessment, prices range between $46 / tonne and $49 / tonne, for chip logs landed at the MDF plant. Historically, prices have ranged between $46 / tonne and $52/tonne. The occasional peak price occurs, often for periods where supply into the MDF plant is uncertain (for example over Christmas) and normally for a very short time. As previously discussed, the Dongwha plant consumes between 350,000 tonnes and 390,000 tonnes of chip per annum, with approximately two-thirds of this consumption derived from logs, and the remainder as chip residue from sawmills.

Export pulp log market

New Zealand's core export log markets in China, India and Korea provide fairly consistent demand for pulp logs. The export pulp logs are cut to a better specification than domestic chip logs, usually being straighter and longer logs. Rather than being converted into chip at the point of sale, they are often cut into low-grade sawlogs and used as temporary building materials (egg. boxing-grade timber).

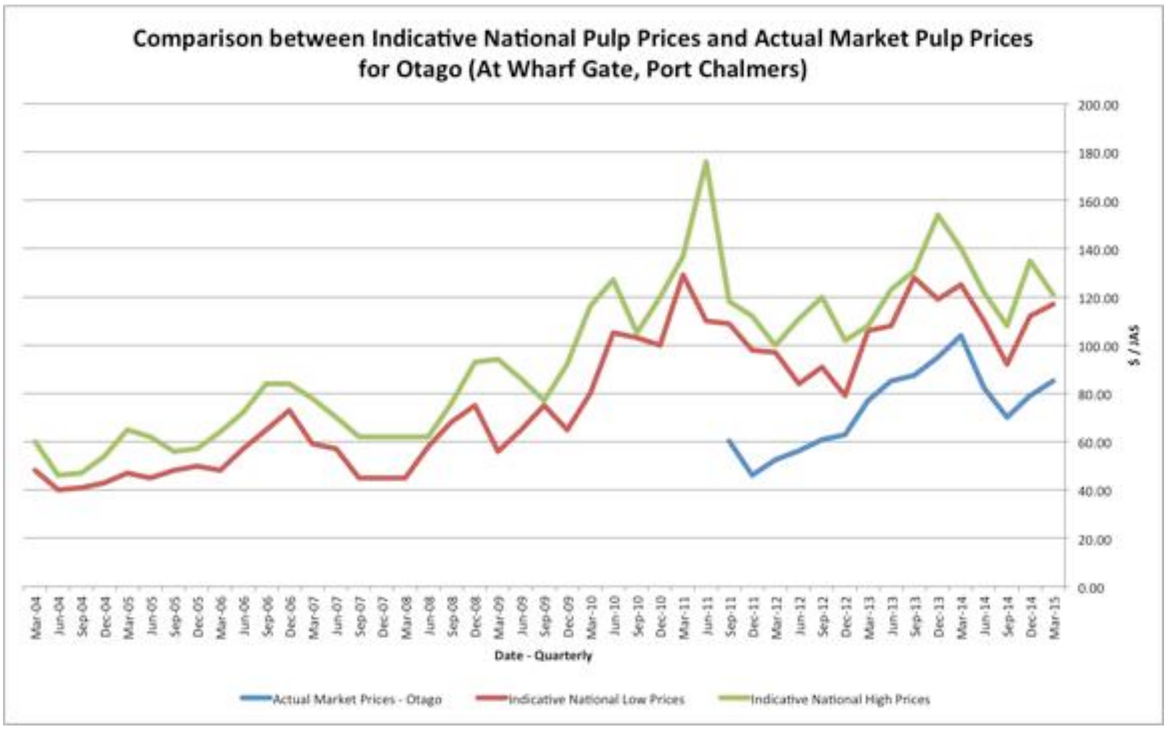

Figure 9 Comparison between indicative national pulp prices and actual Otago pulp prices

Historic export prices are shown in Figure 9 above. The indicative national market prices for pulp were obtained from the Ministry for Primary Industries, and represent the low and high price range from across their national database[1].

The Otago market prices are actual prices that have been received, at wharf gate, over the last four years. The trends are noticeably similar, showing a steady but unpreditickable increase in export pulp prices over time. The rise of the Chinese log market as the dominant purchaser of New Zealand log products contributes strongly to this upward price pressure.

In Otago, the average wharf gate price for pulp logs over the four years to March 2015 is $74 / JAS. A typical log conversion of 0.8 JAS to tonne, equates to an average rate for pulp logs of $59.20 / tonne.

Domestic billet wood market

Billet wood is woody residue of lengths between 1.0 and 3.0 metres, and usually arises as a by-product from harvesting operations. This product is sold to the Mataura-based Dongwha Patina Medium Density Fibreboard (MDF) plant for a sale price that effectively provides the harvesting contractor with some cost recovery value, and the forest owner (CFL) with a small financial return which contributes to the maintenance of roads and overheads. A significant benefit to forest owners of selling billet wood is the 'clean' forest landings that result, requiring less post-harvest management to rehabilitate these sites. The ability to pay the harvest contractors a fee for their handling of this product is also of importance. At the time of this assessment prices paid for billet wood varied between forest owners. The customer, Dongwha, pays the cartage for billet wood, and as such is prepared to pay more billet wood that is in closer proximity to their plant. Prices paid for billet wood have varied between $11 / tonne and $18 / tonne (on truck). Cartage to the MDF plant can be as high as $30 / tonne, resulting in a delivered price to Dongwha of $40-$45/tonne.

Unfortunately the billet wood market is not always reliable. Purchase of the billet wood product is not consistent, but will occur on a site-by-site, day-by-day basis. Forest sites that are increasingly distant from Mataura are less favoured, due to the increasing transportation costs that are paid for by the purchaser. It has been found that providing billet wood is not viable in forests that are over 100 kilometres from Mataura, though collection does occur occasionally.

[1] "These log prices are historical and indicative only and may not correspond to actual prices paid, or grades used, in market transactions. A "best fit" is applied by survey respondents to align company log grade specification with the generic specifications. Direct comparisons with actual market prices may not apply, due to differences between the specification sets. The prices are subject to changes when further data become available". From http://www.mpi.govt.nz/news-and-resources/statistics-and-forecasting/forestry/indicative-new-zealand-radiata-pine-log-prices-by-quarter/ (accessed 25 May 2015).

The lack of reliability of the billet wood market can impact upon the harvest management system. If a sale for billet wood exists, harvest contractors will often stack these short logs for loading out only to find the cartage system is not meeting their output. Given the lack of available space on the forest landings, such accumulation of logs is not desirable, impacting upon the efficiency of the core harvest management system. It is standard practice for harvest contractors to discard the billet wood products over the side of the landings, away from the log storage area. Retaining the space on the landings aids efficiency of harvest operations, and is more valuable than an unreliable market providing minimal financial return. A key lesson here is that for this available woody residue to represent good value to the forest owner it must also possess attributes of reliability and efficiency.

Domestic firewood market

The sale of firewood is another potential outlet for the low-value logs arising from Otago / Southland forest. Radiata pine is not normally demanded by firewood outlets, but Douglas fir, eucalyptus and macrocarpa is consistently sought at prices in the vicinity of $40 / tonne on truck (i.e. cartage is paid by the purchaser). The domestic firewood markets provide consistent outlets for these minor species that have few alternative markets for logs that are out of round wood specification.

Export chip markets

Until 2013, chip logs were commonly sold to local chipping processors who processed the raw log into chips, and then sold into export chip markets. In 2013, however, only 25,500 Bone Dry Units (BDU) were sold from Bluff (MPI, Quarterly Trade data, 2015). Since then, there has been no export of softwood chip from Bluff or Port Chalmers. This is primarily driven by the reduction in global paper manufacturing. There is general agreement by those in the industry that is unlikely to change into the future.

The hardwood chip market is far more consistent, due to the presence of SPFC in Southland. SPFC are owned by paper manufacturers in Japan, and as such, have consistent outlets for their product. In 2013 and 2014, 79,000 BDU and 81,000 BDU were exported from Bluff, respectively (MPI, Quarterly Trade data, 2015).

Wood energy markets

In recent years there has been some purchasing of billet wood grade and chip grade logs from forests that are proximate to Dunedin City. The forests that are close to Dunedin City benefit from these markets for two reasons. Firstly, these forests are approximately 150km from Mataura, and secondly, they are close to some of the larger end users of wood energy. As such, they benefit from the reduced cartage costs on these low-value products. Forest owners receive similar net prices to that obtained for chip logs or billet wood.

7.2 Use of existing sawmill byproducts;

At the time of completing this assessment it was apparent that all of the sawmills within the study area have committed their supply of by-products to existing customers. For the smaller sawmills the primary outlets for their woodchips and shavings included meeting their own fuel needs, supplying the product as a fuel to other existing users, and supplying product to dairy farmers for cattle bedding. All sawmills were happy with their existing situation, appreciating that they were now being paid for a by-product that was traditionally a waste product that was often difficult to deal with.

The Panpac sawmill, though yet to become fully operational, already has committed their supply of woodchip by-product to the Dongwha MDF plant for the short-medium term. There could be good opportunities in the medium term for any of these mills, including Panpac, to supply new markets.

7.3 Capturing wood residue that is not currently sold from the forest site.

In this study, forest residues are defined as the unused portions of plantation trees that have been felled by logging, but remain in the forest unused. These forest residues have some potential to be used as an energy product, if they can harvested and processed at a cost that justifies the return.

Forest biomass supply for energy is typically generated from logging residues. When this material is "green" - immediately after harvesting - the moisture content (MC) is typically 55% MC wet basis (wb), rising to a maximum of 60% MC wb. This material occurs at two key locations within the forest; at landings (roadside skid sites) and at the stump (cutover).

Currently, the standard operating practice within most commercial forests throughout New Zealand is to push the 'waste' residue back into the forest, or to leave it in a pile on the edge of the landing. In both circumstances, the residues are left to decay.

7.3.1 Forest residues generated on the cutover

The amount and type of residue left on the cutover site will differ from site to site, depending on the type of extraction system used and the quality of the trees being harvested. Ground-based harvesting systems (either skidder or forwarder) will typically mechanically de-limb the branches on the cutover site, thereby leaving significant woody residue behind. Whether recovering the stem residues is cost effective or not will be determined by two factors - the quality of the forest itself, and the presence of a market that adequately demands stem-residue product.

Markets must place a suitable value on the existing waste stem wood to enable the recovery of these cutover residues. The small piece size of stem wood being recovered, the relatively low volumes of remaining residue, and the relatively large travel distance between stem pieces, mean that recovery is comparatively expensive. After significant consultation with forest managers as a part of this study, it has become clear that forest managers will not contemplate retrieving wood residue from the cutover site if the net revenue obtained is similar to billet wood. Quite simply, the current returns from billet wood do not justify the extra cost and time associated with the retrieval of this product.

7.3.2 Forest residues generated at forest skid sites.

The forest landing, or skid site, is the main point of woody residue accumulation in the forest. It is at the skid site that the greatest potential exists to recover woody residues for downstream uses.

The amount of residue that accumulates at the forest skid site is influenced by the harvesting system used and the quality of the forest crop being harvested. The residue that accumulates at landings is of a higher priority than the residues accumulating on the forest cutover because of the following reasons:

1. There is a condensed, cumulative volume.
2. The volume of residue is located within a processing site that is well positioned to make use of forest processing equipment that is in place.
3. The harvest contractors have already expended cost and energy harvesting the logs, and need to recover value from it.

As a result of the above, there is a much higher potential for cost-effective recovery of a wood product.

Photo: Stem residue accumulation at a typical forest landing.

For the purpose of this study, woody residue that can be potentially used for wood chip is no smaller than the billet wood grade (1.0m – 3.0m lengths). Numerous studies provide evidence as to the inefficiency of handling very small pieces of residue, and as such these small residues have been discounted.

In addition, many wood chippers will not process log residue of less than 1.0 metre in length. Discussions with the two existing wood-energy suppliers in the region have reiterated this requirement for a wood-residue supply that is a minimum of 1.0m, with a preference for 3.0+ metre lengths. As such, this has been the basis for the utilisation cut-off point for wood chip production.

7.3.4 Estimated unutilised available wood residue.

During this project assessment we have asked forest managers what their assessment is of the available wood residue that remains on the skid site after the completion of the forest harvesting operation. Estimations from forest managers were similar, but spread over a range. For all of the forest managers, the quality of the forest and the distance to market will determine the volume of unutilised wood residue that remains after a harvesting operation.

Previous site assessments of forest skid sites in a suite of Dunedin forests (Millar, 2009) provided the following information regarding the levels of wood residue that accumulate on skid sites. This information has been updated during this assessment, during the course of interviewing forest managers.

Table 2 Estimated recoverable wood residue from forest sites, that is not currently recovered.

>	Poor-Quality Site	Average-Quality Site	High-Quality Site
Total woody residue as proportion of total recoverable volume	30%	10%	4%
Usable woody residue as proportion of total recoverable volume	15%	4%	2%

The table above summarises the expected average log stem residue volumes as a proportion of total harvestable volume that can be expected to be harvested from different quality sites within a normal corporate forest. The usable proportion of the residue is the billet wood grade, or non-saleable chip log grade that has been discussed above.

8.0 Estimated available annual log volume for wood energy from South Otago

The expected woodflows from the project area are shown in Table 3 below. After the year 2025, it is anticipated that wood flows will stay relatively constant until another increase around 2040. Estimated wood chip, pulp, and billet wood volumes are also shown. This analysis demonstrates the increasing availability of lower-value log products within the study area that are available for use.

Table 3 Estimated woodflow volumes in the South Otago assessment area.

	2015-2018 (per annum)	**2019-2024 (per annum)**	**2025-2041 (per annum)**	**2042-2065 (per annum)**
Total Volume	798,000 tonne	1,079,000 tonne	1,298,000 tonne	1,474,000 tonne
Estimated Chip (MDF) volume / annum	65,000 tonne	65,000 tonne	65,000 tonne	65,000 tonne
Estimated additional low-value logs / annum (eg.pulp)	105,000 tonne	172,500 tonne	220,500 tonne	259,500 tonne
Estimated billet wood volume / annum (for energy or MDF)	24,000 tonne	32,500 tonne	39,000 tonne	44,000 tonne
Estimated additional recoverable billet wood / annum	24,000 tonne	32,500 tonne	39,000 tonne	44,000 tonne
Total available chip / pulp / billet wood / annum	218,000 tonne / annum	302,500 tonne / annum	363,500 tonne / annum	412,500 tonne/annum
Total available energy (GJ) / annum (Net Calorific Value)	1,559,000 GJ / annum	2,163,000 GJ / annum	2,600,000 GJ / annum	2,950,000 GJ / annum

The estimated woodflow volumes shown in the table above have been generated from an assessment of various datasets, including data from large forest owners, and regionally focussed MPI wood flow data. The estimated volumes of chip, pulp and billet wood are averages, and should be treated as guiding figures only. Again, these figures have been generated from discussions with local forest managers, and using MPI regional yield data.

8.1 Discussion – availability of residue within the study area.

Woodflows from across Otago and Southland are planned to increase significantly in forthcoming years. Already a considerable industry in the southern regions, forestry is soon to become even larger and significant as a contributor to the regional economy. Over the next decade there will be a considerable increase in the expected harvesting across these regions, with the South Otago area reflective of this increase.

Currently the lower value logs (chip / pulp) are sold to a mixture of local markets, predominately via the Dongwha MDF plant at Mataura, and to the export pulp market via Port Chalmers or Bluff. The proportional split of destinations for these markets is dependent on the forest owner, their market agreements, and their proximity to the markets. However, it is common for 30-40% to be sent to the domestic market, and the balance exported. Forest owners closer to the MDF plant shift greater proportions of their product to the domestic market. All forest owners have contractual agreements with Dongwha, and view this outlet as a cornerstone component of the domestic market.

Forest owners generally agree that the current price paid for chip logs at Dongwha is moderate, but recognise the value of the consistent outlet and the relatively stable pricing. The volatile pricing of the export market is well known, and though not limited to the forestry industry, is an attribute that is often associated with it. The volatility of the export log market has been suitably demonstrated over the last three years, as shown in figure 8 below.

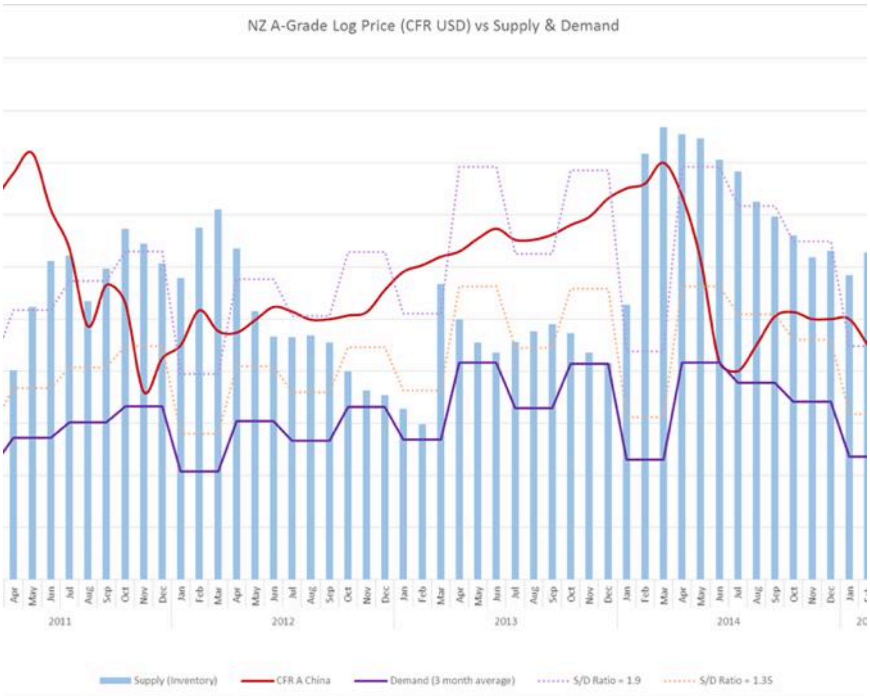

Figure 10 Snapshot of export price fluctuations over time

Though forest owners appreciate the periodically high prices of the export market, they also appreciate the stability of the domestic market. Forest owners recognise the need to support the domestic market, even in times of buoyant log prices, so as to ensure the continuity and viability of a domestic market for lower value logs. However, all of the forest owners spoken to expressed support for an additional competitive market for low value residues. The location of the end user market will dictate its importance to the forest owner, just as the MDF plant does now.

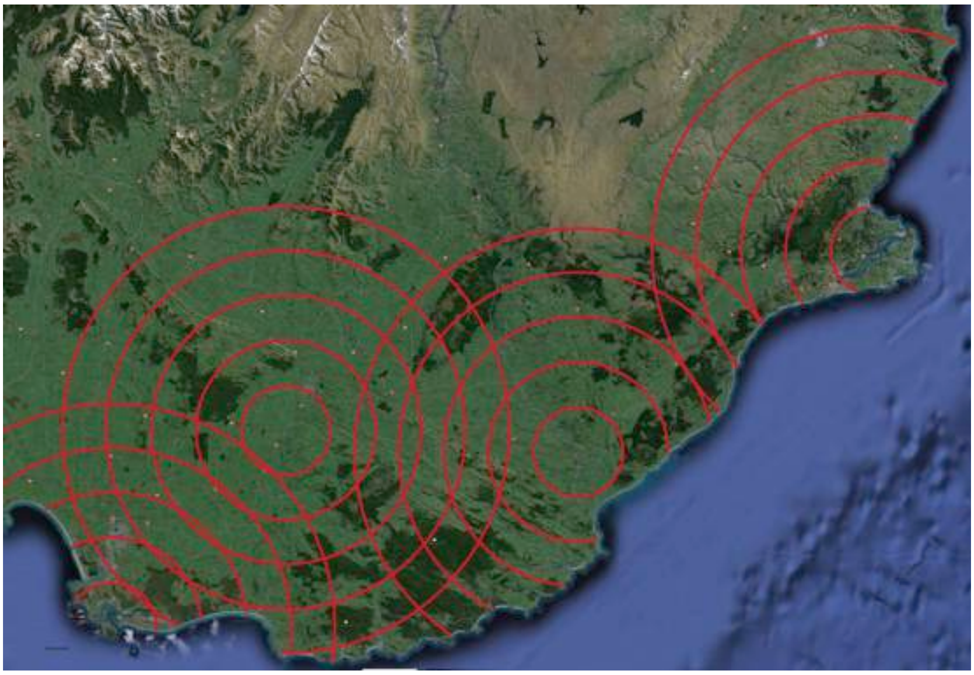

Figure 11 Indicative Proximity of end users to forest resources

The increasing regional forest volumes will provide forest owners with the ability to service existing domestic markets, as well as new markets. Proximity to market place is critical, as is the provision of a stable log price which can provide consistency to forest owners in periods of fluctuating export commodity prices and concurrently continue to be a competitive market when export prices are buoyant. Given the steady-state demand from Dongwha for chip logs, there will be an increasing proportion of the lower value logs available for sale to markets beyond the Dongwha MDF market as the regional forest harvest volumes increase.

9.0 Evaluating the price for wood energy

The price that prospective energy users will need to pay for log product is largely determined by the opportunity cost for forest owners of selling log products in to competing, alternative log markets. The lesser the value of the logs, the greater will be the proportional impact of the cost of production on the net return to forest growers. Proximity to the end market is the biggest single variable cost, creating a significant range of net returns to forest owners, dependent on the forest location.

To evaluate the price that forest owners would need to be paid to gain their commitment to an emerging market, an analysis was completed that assessed the gross prices, associated costs, and net returns for forest owners in a variety of locations across South Otago. The summary of these results is shown below.

Table 4 Net returns to Forest Owner ($ / tonne) to various destinations.

Gross Price ($/t)	$60/t	$50/t	$40/t	$50/t	$40/t
Product	Pulp	Chip	Billet	Energy	Energy Billet
Destination	**Bluff/Chalmers**	**Mataura**	**Mataura**	**Clydevale**	**Clydevale**
Origin	Net price to Grower ($ / t)				
Coastal Otago	$17-$20	$3-$5	$2-$3	$12-$13	$8-$10
Waipori	$17-$20	-	-	$10-$12	$5-$6
Beaumont	$7-$9	$5-$7	$2-$3*	$16-$18	$12-$14
Tapanui	$7-$9	$10-$12	$6-$8*	$11-$13	$7-$9
S.Catlins	$15-$17	$12-$14	$8-$10	$6-$8	$2-$3
N.Catlins	$13-$15	$10-$12	$6-$8	$16-$18	$12-$14

* Is not likely to supply significant billet wood volume.

(green)	Good prospects as a wood energy supply area, for Balclutha / Clydevale.
(peach)	Average prospects as a wood energy supply area, for Balclutha / Clydevale.
(red)	Poor prospects as a wood energy supply area, for Balclutha / Clydevale.

9.1 Discussion

Several key points have arisen from discussions with forest owners, and have been confirmed with the analysis above. The location of the forest areas is critical to the profitability of any of the end markets, and alongside gross price, is the key variable for consideration.

Chip logs, sold to the Dongwha MDF plant in Mataura, provide returns for those forests which are proximate (namely Tapanui and South Catlins) but considerably less for the forests further north (namely Coastal Otago and Waipori). Likewise, the billet wood market provides positive returns to some forest owners, particularly for those in close proximity. However, some of the forest owners close to the MDF plant do not choose to supply billet wood, instead focussing their attention on maximising the recovery of chip logs. The net returns from billet wood rely on harvesting contractors being paid a nominal fee for the loading of this product, and a contribution to forest overheads such as roads. As such, though the net returns are positive to the forest grower, it is considered a less-viable log product due to the inability to pay the harvesting contractor a fair price. Consequently, it is not a log product that is specifically cut, but is a residue that is recovered so as to maximise the recovery of all available resource.

If prices for wood energy are set at levels that are competitive with existing log products of similar quality (chip and billet wood), then it provides an alternative market for forest owners. At $50/tonne ($7.00 / GJ) delivered to the processing site, all forest's benefit from a wood energy market. Coastal Otago, Northern Catlins, Beaumont and Waipori forests return noticeably higher profits from selling to a wood energy market located in Clydevale compared to selling chip logs to Mataura. The Waipori and Coastal Otago forest areas are the biggest beneficiaries of a new wood energy market in the Balclutha / Clydevale area, due to the minimal returns that are currently received for their low value log products now. The South Catlin forests are too distant from Clydevale / Balclutha, and conversely are too proximate to Bluff and Invercargill, to be considered available suppliers of residue.

At $50/tonne, a new wood energy market will compete with an averagely performing export pulp market. For forest owners at Beaumont and Tapanui, the wood energy market becomes more competitive than an average export pulp market. For forest owners at Waipori and Milton, a local wood energy market will strongly outcompete other domestic options (namely Dongwha) but will not outcompete an average export pulp market.

Potential users of wood energy in Balclutha or Clydevale are very well located for forest owners seeking an alternative market to Dongwha or export pulp. Forest owners in Waipori, Beaumont, Northern Catlins and Coastal Otago will all benefit from local domestic demand for wood fuel. Owners of forests in Waipori are particularly isolated from domestic markets for lower value logs, and would benefit from a local domestic user of lower value logs.

It is estimated that 80% of the South Otago forests within the project area would benefit from a local domestic market for lower value logs. The remaining 20% of the forests within the area are too remote from likely end users in either Clydevale or Balclutha, for those destinations to provide viable markets for lower value residues.

10.0 Delivering the wood fuel to the end user.

This section of the report discusses the options for delivering the wood fuel to the end user, and provides a recommended best option.

10.1 Residue recovery options

There are five main production and delivery systems that can be used when recovering residues for downstream energy use:

- Raw biomass material transported directly from forest to the end user and then processed.
- Raw biomass material transported from forest via a central yard or storage point to the end user and then processed.
- Raw material transported from forest to a central yard for processing and/or storage. Wood fuel is transported to the end user.
- Raw material processed at forest landing and wood fuel transported to a central storage yard then transported to the end user.
- Raw material processed at forest landing and wood fuel is transported directly to the end user (EECA, 2014:27).

Those with the least handling steps are generally the most efficient. Intermediate handling and processing will usually add cost. However the specifics of each situation, including transport distances, will determine which option is the most efficient.

There are two options for timing the collection of wood fuel from the landing, which influence the potential options for subsequent processing. They are:

- Post-harvest recovery.
- Integration with log harvesting

10.1.1 Post Harvest Recovery

There are three obvious disadvantages in recovering the waste residue from an abandoned skid site:

- Typically bulldozers or skidders push the residue into 'birds nests' with significant amounts of soil contaminant mixed in. This contamination provides difficulties when wanting to chip the product, ultimately lowering the quality of the product.
- To store the log residue product effectively will require extra storage space, or will compete heavily for the existing space on the landing.
- Additional handling equipment is needed to handle the woody residue in a separate operation, after the harvesting operation is complete. This additional handling adds significant cost, estimated at $4/tonne of product handled.

The space requirements for woody biomass are a significant limitation for forest managers considering the recovery of log residues after harvesting operations. Topographical limitations, especially in the steeper forests within the Clutha area, create restrictions in the size of the forest landings that can be constructed. Typically the forest skid sites are 35 metres wide by 70 metres long, creating a footprint of 2450 square metres. Hauler pads are usually in addition to the landing area.

Harvesting crews will spend on average between four and six weeks at each harvest landing, harvesting a forest area of between 4-12 hectares. During this period the rate of accumulation of woody residue will compound rapidly. It is normal practice to process between 4000m^3 and 7000m^3 of harvestable log product on each landing. 5,500 – 6,000m^3 of recoverable volume is quite typical but there can be significant deviations either side of this figure.

These estimations are reinforced by Visser et al (2009:5), who undertook a survey of New Zealand landings, showing that the median value of landing use is 3 weeks, corresponding to the accumulation of 15-25 truckloads (about 375-625 t) of biomass per landing at the end of that period.

"Exploring the option of stacking the residue on the landing, we can calculate the space this would take up, if properly stacked. Assuming 100 kg m^{-3} as the bulk density of loose logging residue, the 400 tonnes accumulated at a landing would represent 4,000 m^3, and organized in 3 m tall stacks (considering 3 m as the maximum height at which a loader can comfortably stack such material) would occupy a surface of 1,200 m^2." This equates to a half of the typical forest skid site, making it impractical to store the residue on the same skid site that the operations are occurring on.

10.1.2 Transporting to disused skid sites

Transferring the log residue to a disused skid site or landing is an option. The best possible method for a short transfer to occur would be by using large (40m3) hook bins. As the harvesting crew processes the logs, the log residue is thrown into the hook bin directly. This will provide a clean residue product, and will ensure the skid sites are kept clean without impacting significantly on the harvest operation. However, there would be significant capital cost attached to such an operation. Three hook-bins would need to be rotated for each harvest operation that is underway. Also, dedicated hook-bin trucks would be used to transport the bins.

Again, there is insufficient volume from each harvesting operation to justify individual cartage units. The potential to share amongst crews is only moderate, due to the potentially wide distances between the crews across the various forests. At each central yard, there would be a need for the log heaps to rebuilt to allow maximum use of the site. This would demand extra handling equipment, which could be rotated around each forest. Also, moving loose residues with low bulk density can add significant cost to operations and requires careful evaluation.

The processing equipment (chipper/hogger) must be mobile to travel from landing to landing. The volume at each landing might be in the order of 250 to 350m^3 of solid wood. For a large chipper/hogger that is only 8 to 10 hours' work meaning the machine will have to shift site every day or so, with significant production down time.

When chipping on landings it will be difficult to chip or hog directly into a truck due to limited space or placement of raw material, so discharge to ground is likely, leading to fibre loss, risk of dirt and moisture contamination, and lower production. Lastly, forest managers will usually try to rehabilitate skid sites as soon as possible after harvesting, so that they can be replanted into the next crop. For all these reasons, chipping at landings is often not a preferred option.

10.1.3 Integration of wood energy recovery, during harvesting

Handling the wood residue as a component of the wider harvesting operation has a number of advantages, including the ability to use the harvest crew's on-site machinery to handle the residue. The advantage to a harvesting crew of clearing log residue from the processing site in an efficient manner has obvious economic and safety benefits. The potential cost savings with such a system arise from the reduced handling of the residue product, as the product does not need to be re-handled. The continual clearing of the skid site will provide a clearer work site, and thus a safer and more efficient work environment. Such a system would require additional planning and adaptation from the existing harvest system, and depending on its configuration, may require additional space on the processing site.

Chipping on site, during harvesting operations

When considering the use of a chipper on site, so as to sit alongside the main harvesting operation, the space limitations would not accommodate either the chippers or the transporters. In addition, within the context of the Otago plantation resource, the volume of biomass that accumulates on a daily basis is typically too little to justify integrating a comminution machine on site.

10.1.4 Shifting logs off site, during harvesting operations

The three remaining supply chain options can be described as:

1. Load bin or truck with woody biomass as harvesting progresses / truck direct to end-user / accumulate and store / hog or chip to wood fuel storage.
2. Load bin or truck with woody biomass as harvesting progresses / truck to CPY /accumulate and store / truck to end user for processing.
3. Load bin or truck with woody biomass as harvesting progresses / truck to CPY /accumulate and store / hog or chip at CPY / truck wood fuel to end-user.

The methods for removing logs from the site are described below:

- Stockpile and load out as a log product. In this option, the woody biomass is treated the same as other log products, that is, it is stacked up on the landing and when a truckload is available a truck is requested and the material is loaded out. This system assumes there are sufficient suitable trucks available to remove the material on an 'as required' basis. If truck scheduling is inadequate, problems will occur. Production of the biomass material is a cost to the logging operation in terms of handling and loading and the logging contractor should be compensated for this.

- Load to bins or setout trailers and truck out as filled. This requires leaving the bin or setout trailer at the harvesting crew and retrieving it when full and leaving another empty one with the crew. The bins can be left singly or in pairs and retrieved using a hook system like a jumbo bin or a semi trailer can be left on the landing for the crew to fill.

  A study of the use of setout bins in New Zealand (CEC, 2009) recommended the use of two bins delivered by truck and trailer where possible. This approach should lower cost as the machines are on site and downtime associated with moving to and from the site is minimised. Setout bins should also lead to lower levels of dirt contamination. It is likely that the trucks would need to be fitted with central tyre inflation systems to access landings in winter or wet conditions.

The down side of the bins is that the transport system has a higher tare weight and lower payload than a conventional truck, and so is higher cost for longer haul distances.

- Stockpile and load out using self-loading trucks. The third option is to stockpile the residues and load-out after the logging crew has left. As discussed above, this is not a practical option, as there is insufficient space on the landings to store large areas of biomass. Self-loading trucks would typically be used to pick up material from a landing after the logging crew has left, as self-loading trucks are slower in loading, and suffer from a tare weight penalty, due to the weight of the crane and stabilizers.

10.2 Chipping

There are three main options when considering where to process the stem residue. These are, either:

1. Chip at a yard, external to the forests.
2. Chip in-forest, after the harvest operation. This has already been dismissed, as described above.
3. Chip in-forest, during the forest operation. This has already been dismissed, as described above.

Chip at a yard, external to the forest

To retain a profitable margin from the sale of any low-value woody residue, the supply system must ensure that the logs are handled as little as possible. Any extra handling of the log residue will add unnecessary cost to the operation, estimated at \$3-\$4/tonne per handling movement.

Chipping the raw material at the end user (such as a heat plant or further processing facility) has the advantage that the discharge can go directly into fuel storage or heat plant input, minimising handling costs, fibre loss and contamination risks. Large scale fixed location comminution machinery is typically also the lowest cost. However, this may not be a viable option for all due to space requirements for raw material storage and processing facilities. (EECA, 2013:26)

Chipping the product at a central process yard has the advantages of keeping chipping equipment in one site and minimising the potential for under-utilisation of the equipment. All other things being equal, if the log residue supply is maintained at sufficient levels to allow for constant throughput through the chipper, then there will be minimal down time. Larger chippers and hoggers that are able to cope with almost any sized material are expensive to buy and run. While they have higher throughput, they must be able to work close to capacity in order to minimise operating costs. A key consideration is whether the throughput capacity of the chipper or hogger matches the supply of raw material and the demand for product.

Alternatively, chippers can be transported to the central process yard as and when required. This is a viable option when limited volume of chip is being produced at any one site, and the capital cost of a chipper is not justifiable for the limited volume being produced.

A number of studies in New Zealand on drying radiata pine have shown that in good conditions it is possible to reduce moisture content relatively quickly. The main climate factors that dictate good drying include high air temperature, low humidity, good pile airflow and wind. The main storage consideration is stacking, or at least piling the wood. This reduces the amount of wood in ground contact and the impact of rainfall. Wood spread out and in contact with the ground does not dry as well as stacked or piled material.

10.3 Summary table of the Potential Supply Chains

The table below summarises the key advantages and disadvantages of each of the options that have been discussed.

Production of chip within the forest	Advantages	Disadvantages	Assessment
Option A: Mobile chipper, during harvest operation	1. Handling equipment present on site	1. Insufficient space on skid site. 2. Difficult to maximise utilisation of chipper.	Not viable
Option B. Shift logs to CPY within forest, then chip	1. Easy to shift from the skid site.	1. Need additional equipment within each forest area. 2. Additional capital investment in hook bins and trucks 3. An additional handling step required. Costly. 4. Requires good-quality infrastructure to accommodate trucks.	Low
Option C. Shift wet log residue from forest to external CPY during harvest operation	1. Easy to manage as part of the daily harvesting operation. 2. Good ability for total quality control; including chipping in centralized location. 3. Chipping direct to storage, retaining a quality product. No contamination. 4. Less product handling	1. Transporting a low-energy, high-moisture product from forest to CPY	high

10.4 Recommended supply chain

Option C above is the most effective and feasible method for producing a quality wood chip product from South Otago forests. This wood chip supply pathway is consistent with current harvesting systems, with little deviation from current practice for harvesting crews. There is potential for fine-tuning this system, with the use of hook bins being one example, as awareness develops around the real-time requirements of handling the stem residues.

The logs would be stacked as per other log products, and loaded out as per other log products, with removal on a regular basis. It would be important for the cartage operators to keep trucks up to the harvest contractors to ensure that landings do not congest.

Use of 40m^3 hook bins on the landing has merit. As harvesting crews produce the woody residue, it is thrown immediately into the awaiting bin. Cartage management is essential, with bins being removed immediately. The placement of a hook and towrope on the front of each bin will allow the harvest contractors to shift the bins from the landings when required. A secondary bin on each site will allow for rapid turnaround, with cartage contractors being able to quickly unload an empty bin and upload a full bin without impacting upon the forest harvesting operation.

Comparing this system to the traditional log and load system, there is a greater handling component with the traditional log and load system and a higher potential for contamination of the log residue. The advantage of the traditional log and load system is that it exists now, and as such it will not involve any additional capital expenditure from forest owners or cartage operators.

10.5. Developing a central processing yard for wood chip production

Long-distance cartage of low-value wood residue is not economically viable, and as a consequence, processing must occur within close proximity of the forests producing the logs. Central processing yards (CPY) also need to be as proximate as possible to the end use, and ideally, are at the site of end use. Other attributes of a good site include:

- ✓ Dry, and open to log-drying winds.
- ✓ There is plenty of flat land, a weighbridge and under-utilised equipment such as a wheel loader.
- ✓ There are no resource consent difficulties.
- ✓ Cost-effective rental price.

Determining the best location for a CPY will be led by the need to most effectively service early cornerstone customers, as well as by securing the most commercially viable site.

It will be important to ensure sufficient wood chip is available during periods of high demand, and to have sufficient storage cover to ensure the quality of the stored wood chip. Any storage facility would need to provide for first in – first out rotational handling, minimising the possibility of inadvertent long-term storage through inability to access the older material.   It would also be prudent to monitor the temperatures of the piles. The best cover for the chip product is a non-contact roof that allows for breeze flow through the site and for any moisture and heat build-up to escape. The ideal storage unit would entail three sides and a roof, with concrete floors and a rear concrete wall. This structure would allow for shifting and loading of the wood chip. There will need to be sufficient space within the storage shed to allow for free movement of machinery, especially when filling the hopper.

10.6 Recommended supply chains for large users of wood energy

Any large-scale user of energy would benefit from having their own log storage site and processing yard on site, and processing at the site of energy consumption. An on-site storage and processing system will minimise the handling of log products, and allow for greater control of the supply chain. For the energy user, they would need to invest capital in storage and processing machinery (chipper, excavator, loader), and buy log products direct from the forest owner or via a log marketing agent. Logs will be delivered on a daily basis, temporarily stored, chipped, and then used. It would be necessary for the energy user to maintain a buffer of log stocks so as to ensure that consistent supply was available at all times.

11.0 Cost of energy

The various cost components of wood fuel, for end users in Balclutha or Clydevale, are outlined as follows:

1. Logs, delivered to site: $50-$60 / tonne.
2. Chip to fuel pile, on site: $15 - $20 / tonne.
3. Load to hopper, as required: $5/ tonne.
4. Management and overheads: $5 / tonne.

Total cost $75 - $90 / tonne, or $8 - $9.70/ GJ (GCV), or $10.50 – 12.50 / GJ (NCV).

The Gross Calorific Value (GCV) is the total energy in the wood, and is often the conversion figure used when considering the cost of delivered fuel, prior to combustion. A GCV of 9.28 GJ / tonne has been used in the calculations in this report.

Net Calorific Value (NCV) is the net energy content of the wood fuel, including the energy required in burning off the moisture. The NCV reflects the true cost of energy. A NCV of 7.15 GJ / tonne has been used in the calculations in this report.

(http://www.eecabusiness.govt.nz/wood-energy-resources/biomass-calorific Accessed on 15 July 2015).

The range of prices paid for the logs reflect previous discussion within this report. $50/tonne is a recommended market price to be paid for full-length log product. Depending on the distance to the end user, a billet wood log price of $35-$40 / tonne is likely. The smaller piece size of billet wood means that processing and handling costs will be higher, and as such, will result in a similar end price to the user.

The chipping cost differs too, and will ultimately be determined by the productivity requirements, the infrastructure in place to support that productivity, and the efficiency of the utilisation of that infrastructure. The quality of logs secured will also impact upon the productivity of the chipper, and the cost of chip production. The quality of logs secured will, in part, be determined by the price paid.

Acknowledgments

Many thanks to the various forest owners and sawmill owners who participated in this study, and provided information to enable its completion.

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1. Estimated processing of roundwood from New Zealand forests by wood supply regions, 2002 to 2014.
2. Estimated roundwood removals from New Zealand forests by wood supply region, 2002 to 2014.
3. Quarterly trade figures.

Appendix 1.0

Large forest owners within the project area.

The corporate forest owners within this project area are described in this section.

City Forests Limited (CFL)

CFL owns and manages approximately 16,300 hectares of planted forests, located within a 80km radius of the City of Dunedin. The company is managing its forests at long-term sustainable levels of between 270,000 and 300,000m3. Radiata pine makes up 82% of the planted forest area, with most of the balance in Douglas fir and cypress.

Within the area that is subject to this assessment, CFL have forests in the Waipori area and the Coastal Otago area.

Wenita Forest Products Ltd (Wenita)

Wenita is one of the larger forestry companies in the Otago region, growing high quality radiata pine for local and international markets. Wenita manages approximately 28,000 hectares in Otago, harvesting at a sustained yield of 350,000m3 / annum.

Within the area that is subject to this assessment, Wenita have forests in the Waipori area and the Coastal Otago area.

Ernslaw One Limited

Ernslaw One operates in both the north and south island, with a significant forestry operation in Otago and Southland. In Otago and Southland, Ernslaw One owns and manages 29,323 ha of forest estate, of which 22,500 ha is in a commercial forest crop. Within this study area Ernslaw One manages 14,000 ha of commercial crop.

Within the area that is subject to this assessment, Ernslaw One has forests in the Beaumont and Catlins forest areas.

Rayonier New Zealand Limited / Matariki Forests

Rayonier NZ Ltd manage the 41,000 hectare Otago / Southland Matariki Forest estate. Of these 41,000 hectares, 30,000 hectares is plantation forest. Over the next decade, Rayonier will harvest 420-450,000 tonne / annum. Their forecast is for that amount to increase to 450-500,000 tonne per decade from there on in.

16,000 hectares of this plantation forest is located in the study area, split fairly evenly between the Waipori forest area and the Catlins forest area.

Calder Stewart Forestry Management Ltd

Calder Stewart own 1293 hectares of forest in Coastal Otago, primarily in the vicinity of Milton. Predominately radiata pine, they also grow macrocarpa and Douglas fir. The forest estate is fairly evenly spread, but is a younger first-rotation resource. Calder Stewart is soon to start harvesting their estate under a sustainable yield regime.

Trinity Forests

Two more large plantations were established in this project area in 1999/2000. The Trinity forests, managed by PF Olsen, are spread over two areas – Pinelheugh forest (893ha) and Teviot forest (662ha). Both forests are located near Roxburgh at the eastern end of Central Otago, some 100km from the Otago coastline and Milton. These forests are planned for 50-year rotations, with only small-scale production thinning taking place in the interim years. The proximity to the large sawmills in coastal Otago, means that the majority of logs produced from the Trinity forests will be sold to these destinations.

Appendix 2.0

1.0 Otago Forest Resource

In 2014, the forestry consultants Indufor Asia Pacific Limited (Indufor) completed wood availability forecasts for the Ministry for Primary Industries (MPI). This is described further in Section X.XX. The analysis within the Indufor report is completed at a regional level, rather than a district level.

The Indufor report (2014) describes Otago as having a plantation resource of 123,400 hectares, spread across the five territorial authorities. The majority of the resource, with 82 200 ha, is concentrated in the Clutha District.

1.1 Otago age class distribution

The age-class distribution of the large-scale owners' estate (below) shows a fairly even-aged forest structure, over time. There is about 2,000 hectares in most age classes up to age 20. From ages 20 through to 30, there is an average of approximately 1,200 ha in each age class.

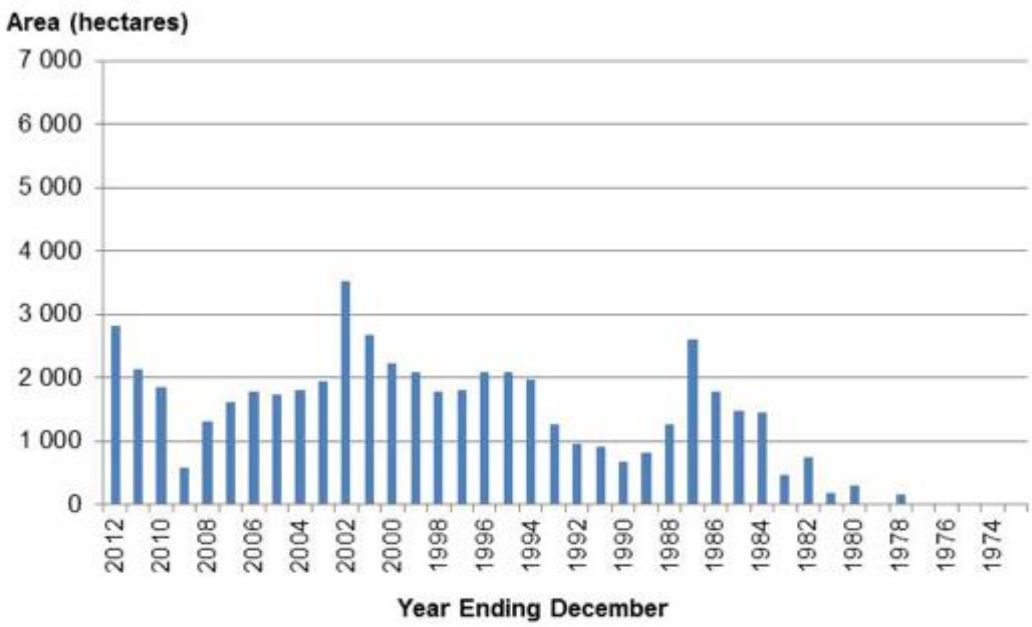

Figure 12 Otago Age Class Distribution of Radiata Pine – large-scale owners, as at 1st April 2013 (Indufor, 2014).

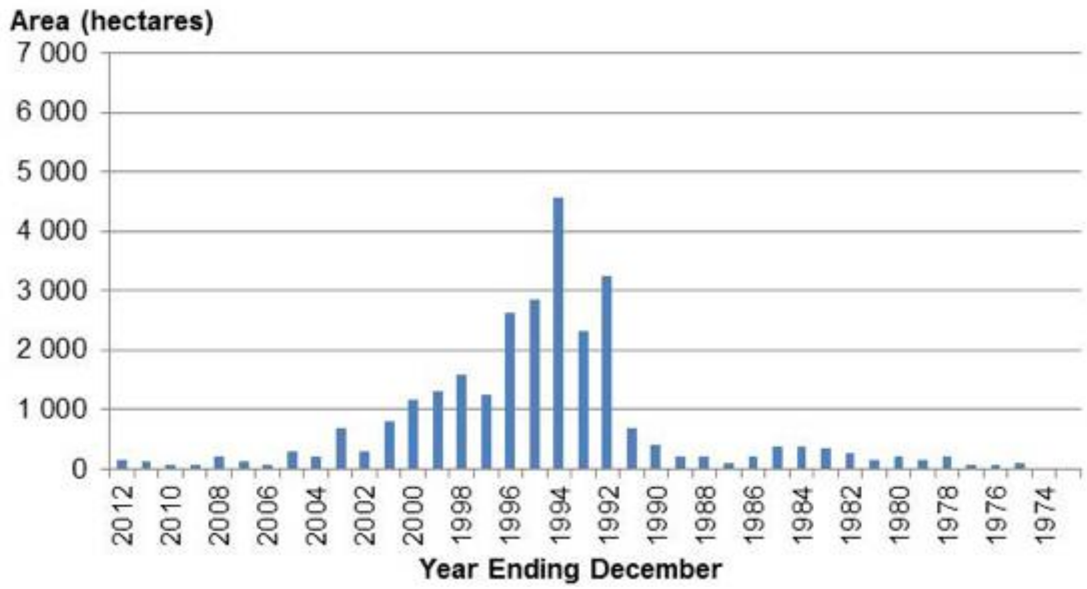

Figure 13 Otago Age Class Distribution of Radiata Pine – small-scale owners, as at 1st April 2013 (Indufor, 2014).

The age class distribution of the small forest owner's estate (above) is very irregular, with large amounts of planting occurring between the years 1992 and 1996 (averaging 2000 hectares per annum), and much less in every other year. The future wood availability from the small forest estate is significantly affected by this mid 1990s peak in planting.

1.2 South Otago Forest Resource

The Otago region has a plantation resource of 123,400 hectares, spread across five territorial authorities. As at 1st April 2013, 82,200 hectares is within Clutha District.

1.2.1 Background data

In 2014, National Exotic Forest Database (NEFD) questionnaires were sent to all known forest owners and managers with at least 40 hectares of planted production forest. A response rate of 96 percent was achieved for owners with more than 1 000 hectares and 89 percent for owners with areas between 40 and 1 000 hectares. In addition to the data collected in the NEFD surveys, the results from the 2004 AgriQuality (now AsureQuality) Small Forest Grower Surveys continue to be used in the 2014 NEFD dataset. (NEFD, 2014)

The NEFD publication states "finer scale data, such as the area by age class at a territorial authority level, is likely to be less accurate than the total national forest area. Forest areas are sometimes misallocated between adjacent territorial authorities. One way for users to minimise this problem is to aggregate data from adjacent territorial authorities, particularly where contiguous forest areas straddle territorial authority boundaries"(NEFD, 2014:6). The NEFD disclaimer has been noted, and stated figures analysed during this assessment, confirming reliability and applicability to this work.

1.2.2 Forest areas subject to this report

This report is primarily focussed on the Clutha District, but due to the proximity of Dunedin City coastal forests to potential users of wood energy in Balclutha and Clydevale, a small area (2,200 hectares) immediately abutting the northern boundary of the Clutha District has also been included. The photo below shows the extent of the project area.

1.2.3 Forest Areas in Clutha District and Dunedin City

The following graphs have been generated from the 2014 NEFD publication. Readers should place emphasis on the Clutha District forest estate, as it is only the southern portion of the Dunedin City estate that is relevant to this assessment. The following graphs consider the full Dunedin City estate, not just the southern portion.

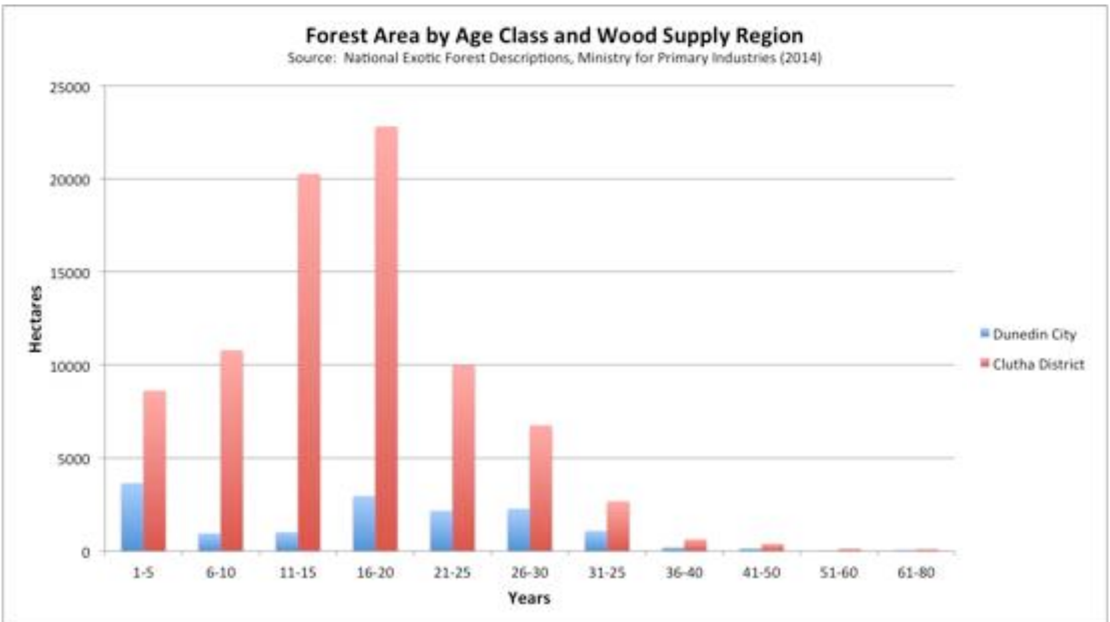

Figure 14 Forest Areas by Age Class and Wood Supply District.

Figure 14 clearly reinforces the earlier discussion about the mid 1990s spike in plantings in the small forest estate. These plantings have lead to a 10-year doubling in the Clutha District forest resource, increasing forest areas from approximately 2000 hectares / annum, to approximately 4,000 hectares / annum over this time.

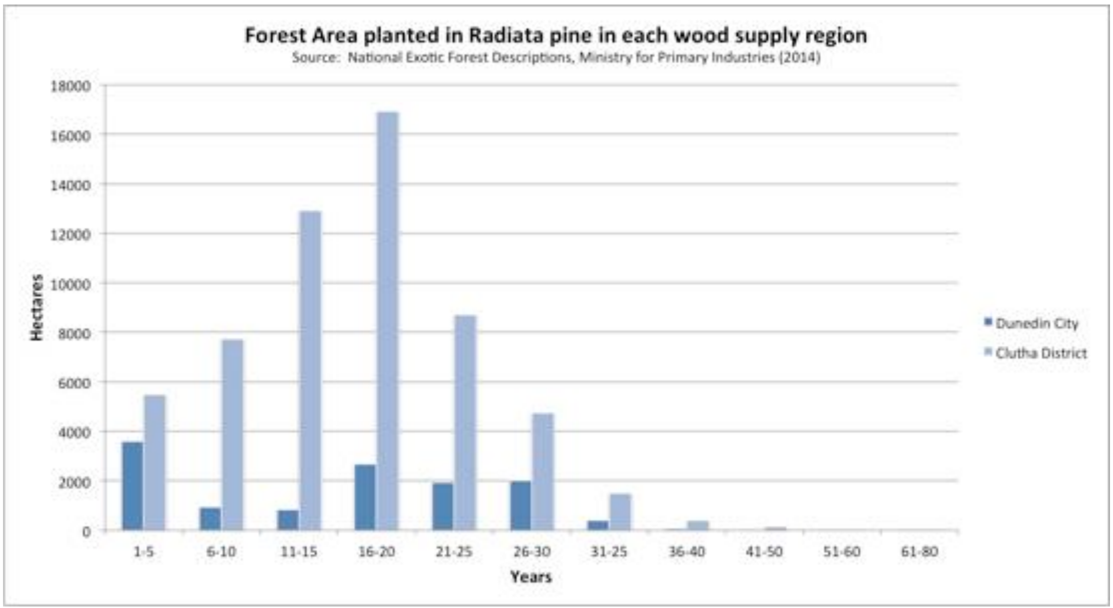

Figure 15 Radiata pine forest area, by Age Class and Wood Supply Region.

Figure 15 shows the dominance of radiata pine in the project area, and again reinforces the sudden peak of plantings that have occurred in the mid 1990s.

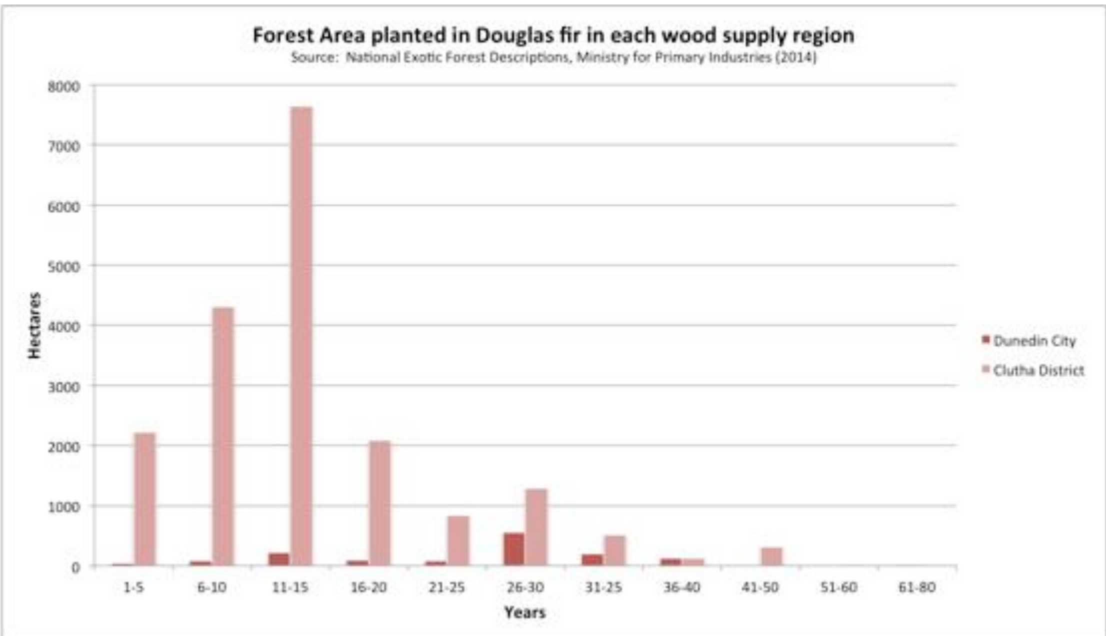

Figure 16 Douglas fir forest area, by Age Class and Wood Supply Region.

Douglas fir is the second most important, and widespread, forest crop in the Clutha district. Like radiata pine, there was a surge in plantings in the mid 1990s, primarily driven by investment syndicates. The longer rotation (40-45 years) Douglas-fir forests have the potential to even out future wood flows in the district. Within the project area, most corporate forest owners have a significant proportion of Douglas-fir forest. It is grown due to its ability to handle cold climates and altitude, the demand shown for the Douglas-fir product, and the diversity that it provides forest owners.

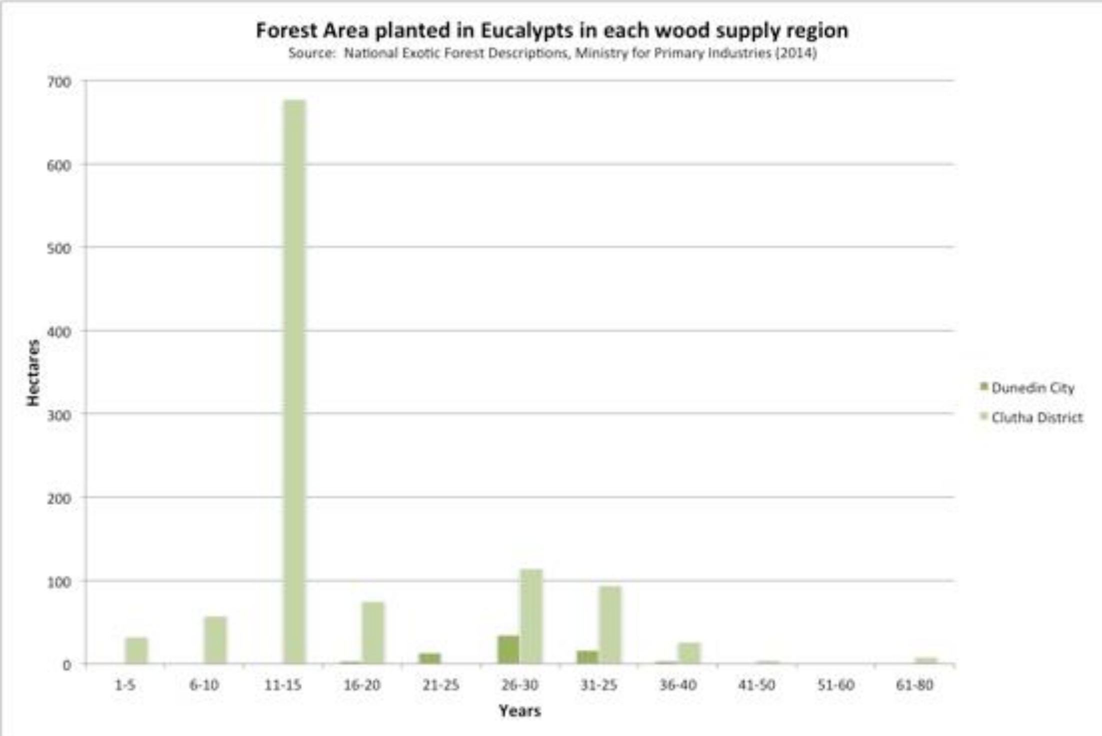

Figure 17 Eucalyptus forest area, by Age Class and Wood Supply Region.

Figure 17 shows a large spike of plantings of Eucalyptus, which occurred, in the mid 1990s. These plantings are primarily due to one corporate forest owner, who specialises in growing eucalyptus hardwood for export chip.

Most of the corporate forest owners interviewed for this project managed only small areas of eucalyptus forest within their wider forest estate, and were often working towards harvesting them with a view to replanting into another species. This is due to their lack of value in the commodity markets.

However, the Southern Plantation Forestry Company of New Zealand (SPFC) is a significant owner of eucalyptus plantations in Southland, but with approximately 1,035 hectares of forest in the Clutha District, including indigenous forest reserves. The spike shown in the graph above is attributable to these plantings.