Technical Report

Analysis of the treated wood market for agricultural and horticultural uses in New Zealand

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Date: December 2020

Report: SWP-T114

EXECUTIVE SUMMARY

This study analysed the treated wood market for agricultural and horticultural uses in New Zealand. Treated wood refers to fence posts for stock and crops, kiwifruit pergolas, vineyards posts and other horticultural supporting structures. Radiata pine (*Pinus radiata*) is the predominant species used in these industries and requires chromated copper arsenate (CCA) preservative treatment for outdoor application. This research is pertinent as there are concerns about CCA treated wood disposal, while there has been no publicly available analysis of the market. The information presented here will aid the New Zealand Dryland
Forests Initiative (NZDFI) and elucidate the importance of the small dimension log resource.

Three sources of data were used to produce independent estimates of the market:

1. a use per hectare estimate
2. a manufacturers' estimate
3. a resource use estimate

It was estimated that approximately 6.9 million m^3 of CCA treated wood is currently present in the agricultural and horticultural industries using the use per hectare method. This presents a significant disposal liability, with policy and a country-wide disposal strategy potentially required. Annually, based on sector expansions and replacement rates, ~290,000 m^3 per year is used. The manufacturers' method estimated a range of ~270,000 m^3 to ~310,000 m^3 per year based on information from two independent CCA organisations. Lastly, the resource use method estimated ~390,000 m^3 per year based on forest grower surveys.

The market is most likely between approximately ~270,000 m^3 to ~310,000 m^3 per year, as the resource use estimate presumably overestimates as survey responders indicated that house pile, pulp log, saw log and firewood volumes were included. The use per hectare estimate may also be an overestimation as non-wood products such as plastic and metal posts were not accounted for although experts indicated that these products only represent a small proportion of the market.

From the NZDFI perspective, the organic sector estimate of ~6,000 m^3 per year to ~14,000 m^3 per year is relevant. The lower estimate is based on a conservative expansion rate, while the upper estimate uses a high expansion rate, indicating the range. Further work regarding the feasibility of the NZDFI alternative eucalypt products is appropriate.

Concerning the small dimension log resource, the importance to forestry companies tends to depend on regions. Roundwood producers are concentrated in the Nelson, Central North Island (CNI) and Northland regions which are areas with low fertility soils typically producing trees with less taper and smaller branches. The requirements for roundwood products are reasonably strict and prices generally do not justify their production in comparison with the main competition of export pulp and K grades. This was especially true for forests located near ports.

TABLE OF CONTENTS

Executive summary 2
CONTEXT 4
1. Introduction 5
2. Problem statement and objectives 6
  2.1. Lack of information and misclassifications 6
  2.2. Chromated copper arsenate concerns 6
  2.3. Small-dimension timber resource opportunities 7
  2.4. Research questions 7
3. Review of literature 8
4. Data and methods of analysis 11
  4.1. Use per hectare 11
    4.1.1. Pastoral agriculture 11
    4.1.2. Vineyards 16
    4.1.3. Kiwifruit 17
    4.1.4. Apple 18
    4.1.5. Organic sector 18
  4.2. Manufacturers 19
  4.3. Forest growers 19
5. Results and discussion 20
  5.1. Use per hectare 20
    5.1.1. Pastoral agriculture 20
    5.1.2. Total size and annual market demand 21
    5.1.3. Organic sector 21
    5.1.4. CCA liability 22
    5.1.5. Alternatives to treated wood 23
  5.2. Manufacturers 24
  5.3. Forest growers 25
    5.3.1. Pro-rata approach 25
  5.4. Comparison 26
  5.5. Log specifications and postwood log market 27
  5.6. The supply chain for treated roundwood 28
6. Areas for further study 29
7. Conclusion 29
8. References 31
9. Appendices 34
  9.1. Appendix 1 34
  9.2. Appendix 2 35
  9.3. Appendix 3 36
  9.4. Appendix 4 37
  9.5. Appendix 5 38
  9.6. Appendix 6 40
  9.7. Appendix 7 41
Acknowledgements 42

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CONTEXT

This is the reformatted dissertation of Boris van Bruchem for the BForSci(hon) degree, which was supervised by David Evison and Clemens Altaner. The dissertation in the original layout can be obtained from the authors or the School of Forestry.

The study addressed Milestone 2 in the SWP work plan WP131.

supported by forest growers commodity levy

FOREST GROWERS RESEARCH

1. INTRODUCTION

The forest industry contributed $1.91 billion to New Zealand's GDP in 2019 (Infoshare, 2019), while the other primary sectors of agriculture and horticulture were also prominent in New Zealand's economy (Westpac, 2016). Horticulture contributed $2.06 billion, while sheep and beef and other livestock farming contributed $4.21 billion in addition to dairy farming's contribution of $6.16 billion to New Zealand's GDP in 2019 (Infoshare, 2019). Although each of these industries has been analysed extensively, little has been published about forestry's relationship with agriculture and horticulture. Specifically, there is little publicly available information about the treated wood market for agricultural and horticultural uses in New Zealand. Ostensibly, this market is significant, with these primary industries playing a key role in New Zealand's economy.

Roundwood is a term commonly used to define both posts and poles, including other materials such as strainers, half rounds, quarter rounds etc. There is a continuous transition in terms of production of posts to poles, with compliance to building and construction standards such as NZS3605 (2001), AS/NZS4676 (2000) or AS2209 (1994) necessary for the latter (Altaner, 2020). Generally, roundwood post and pole products differ widely across these industries (Manley & Calderon, 1982). This study looked at fence material for stock and crops, kiwifruit pergolas, vineyard posts and other horticultural supporting structures. It did not include treated wood for retaining walls, power poles, decks, sheds and so forth. As the majority of wood used in the agricultural and horticultural industries is in ground contact, there is a risk of fungal decay. Radiata pine (*Pinus radiata*) is the most commonly used species in these two industries and is the dominant plantation species in New Zealand (Richardson, 1993). However, it is not naturally durable and requires preservative treatments such as chromated copper arsenate (CCA) to be suitable for outdoor applications (New Zealand Timber Industry Federation, 2013).

This study used three different ways to estimate the size of the treated wood market for agricultural and horticultural uses. Firstly, the market was estimated directly from an estimate of the stock of treated wood in these industries and an estimate of service life. This method is an approximation and involved reconciliation to increase accuracy. Secondly, the production of treated wood was obtained from data provided by the manufacturers who use treatment chemicals, predominately CCA. Lastly, production at the forest level referring to the volume of harvested wood that makes up the supply of treated wood provided the third estimate.

This work is useful for the New Zealand forest industry as it can lead to better utilisation and an increased understanding of markets for the small diameter log resource. When producing posts, smaller diameter logs are used, leading to higher value solid wood products. There appears to be a good opportunity to use commercial thinnings or even harvesting residues for posts (Visser et al., 2018). There is also potential for new markets and products to be found for posts (Altaner, 2020). This research will aid the establishment of a naturally durable hardwood resource (Hedley, 1997) as proposed by the New Zealand Dryland Forests Initiative (NZDFI). The NZDFI project was established in 2008 and proposes eucalypts as a promising alternative to treated radiata pine (NZDFI, 2019). The focus is therefore on the agricultural and horticultural markets (Millen et al., 2018b). Manley and Calderon (1982) also noted that in terms of both the number and volume, the greatest demand in these industries is for relatively small agricultural and horticultural posts.

2. PROBLEM STATEMENT AND OBJECTIVES

2.1. Lack of information and misclassifications

There is a lack of information in this subject area. No comprehensive analysis of the treated wood market for agricultural and horticultural uses in New Zealand is available. This makes it difficult to know exactly how much treated wood is being used by the different industries. Dunn (2011) stressed the importance of further research in this field.

In addition to the lack of information about the market, there are also inconsistent definitions and classifications. For instance, the Food and Agriculture Organization (FAO) of the United Nations (2016) reported industrial roundwood as containing the following categories: pulpwood, sawlogs and veneer logs as well as other industrial roundwood. The latter is relevant for this study, as it contains data on roundwood used for fence posts, but there is no specific data on this category.

Evison (2016) confirmed this inconsistency, as he noted that other industrial roundwood does not add up to total industrial roundwood, stating that the reason for the disparity is unknown. The Ministry for Primary Industries (MPI) (2014) also used FAO data, specifying posts as part of 'other industrial roundwood'.

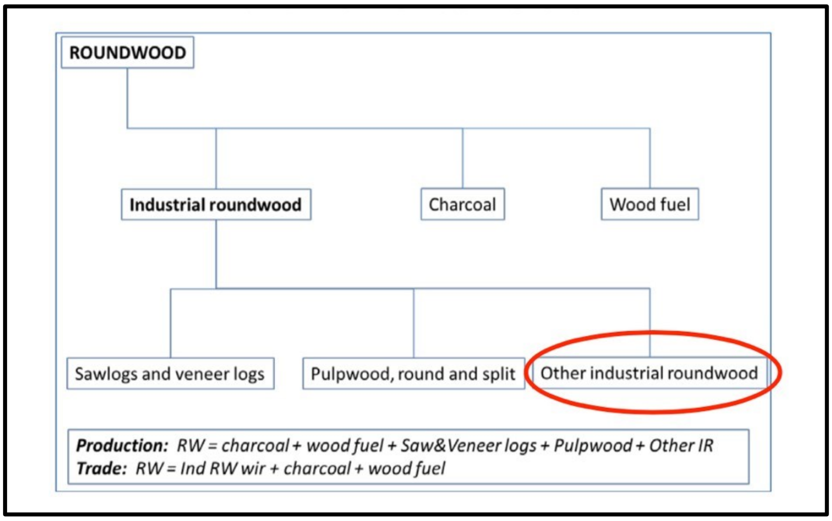

Figure 1. Roundwood classification with the red circle denoting 'other industrial roundwood' (After: MPI, 2014).

Figure 1 shows the distinction of this category, but as is the case with the aforementioned papers, the values are unclear or not reported. The paper notes that there are difficulties in tracking the production and trade of posts (MPI, 2014). They also note that 'other industrial roundwood' was not considered a separate category in FAO trade data since 1997. 'Other industrial roundwood' also included all export logs, which is a large proportion in New Zealand. It was noted that the available FAO data contains many errors and discrepancies between sources.

2.2. Chromated copper arsenate concerns

As radiata pine is not naturally durable and is easy to impregnate, preservatives such as CCA are used extensively where applications require a specific level of wood durability. New Zealand is one of the largest per capita users of CCA treated timber in the world (Christmas, 2002). Radiata pine is by far the most commonly treated species in New Zealand (Connell et al., 1995). However, CCA treated wood is problematic, as it is difficult to dispose of. Burning is prohibited, with disposal methods limited to secure landfills or well-controlled incineration facilities (Rhodes, 2013). Even when disposed of in landfills, treated timber can leach copper, chromium and arsenic into the surrounding soil. This has raised concerns about contaminants in waterways in addition to the soils surrounding the posts (Vogeler et al., 2005). Some soils already exceed the recommended guidelines for chromium and arsenic in agricultural soils as indicated in the report by the National Environmental Protection Council (1999). Vineyards and farms have limited options for disposal and opt to store the posts on site at the end of their service life (Marlborough District Council, 2016), as seen in Appendix 1. With New Zealand striving to maintain its 'clean green image' (Blackett & Le Heron, 2008) and the fact that CCA treatment has been banned in some overseas markets, alternatives to treated radiata pine are being explored.

These alternatives include plastic, steel and posts made of naturally durable timber (Millen & Altaner, 2017). The NZDFI is concerned with the latter since its mission is to research the growth and utilisation of ground durable eucalypt species. This research is therefore beneficial, as the NZDFI can determine how much durable eucalypt timber will be needed domestically. This information is also particularly useful for those in the organic farming and horticultural sectors because the installation of new CCA treated radiata pine posts has been banned in certified organic food production systems (Millen & Altaner, 2017).

2.3. Small-dimension timber resource opportunities

The small-dimension timber resource is poorly understood but provides a very good opportunity for increasing the value of forestry resources. Spinelli et al. (2018) noted that companies can significantly increase the value of their small logs if they sell them as posts for agricultural and horticultural uses. Altaner (2020) noted that post prices with wholesale values of \$300 to \$400 per m^3 are comparable to sawn timber. Furthermore, the utilisation of commercial thinnings and potentially harvesting residues indicates a great opportunity. Therefore, this work will contribute to the knowledge of the small-dimension timber resource and indicate the potential market opportunities for forest growers.

2.4. Research questions

This research addressed the lack of information about the agricultural and horticultural treated wood market which is generally also poorly defined. The outcomes will be useful for the NZDFI, relating to the organic sector and forestry companies who can better understand the market for the small dimension timber resource. Also, knowing the stock of CCA treated posts allows the government and industry to know the size of the risk and liabilities of their disposal. This could be useful in guiding future policy. The following research questions will be addressed:

Overall market

- How many treated wood posts (number of posts and volume) are currently in agricultural and horticultural systems?
- What is the size of the agricultural and horticultural markets for treated wood posts?
- What are the log requirements (specifications) for treated wood for agricultural and horticultural uses?
- What is the importance of the small-dimension log resource for forestry companies?

Organic market

- How many posts (total) are in organic systems?
- How big is the market of treated posts in organic systems?

3. REVIEW OF LITERATURE

Orton and Evison (2009), in conjunction with industry sources, estimated the treated wood market for agricultural and horticultural uses to be 220,000 m^3 per year. They had a particular interest in the winegrowing industry and found that this industry consumed approximately 22,000 m^3 per year or 10% of the total treated market in New Zealand. Millen et al. (2009) estimated that around 900,000 posts per year would be needed for replacing broken posts in vineyards, with approximately 24,000 m^3 per year of hazardous CCA waste produced. This is slightly different from the Orton and Evison estimate and indicates that there is some variation in market estimates.

Carpenter (1994) published a paper about the posts and poles industry in New Zealand and noted that demand fluctuated greatly. He attributed this fluctuation to the increase in kiwifruit production in the 1980s, which saw an increase in demand and also the primary sector downturn in the late 1980s, seeing a decrease in demand. Domestic demand for farming fence posts was forecasted to remain consistent through the 1990s and largely follow the economic peaks and troughs of the sector. He indicated that farming and horticulture dominate the treated wood market with vineyards in particular becoming significant users of posts. It was estimated that from 1986 to 1987, 312,000 m^3 of treated posts and poles were processed in New Zealand. Carpenter (1994) noted that this figure likely remained consistent through some of the 1990s with data no longer collected after this period. This estimate contains wood for many uses such as residential, construction, engineering, marine and recreational. Therefore, the treated wood used just in the agricultural and horticultural industries is likely lower than this figure. As part of the study, Carpenter (1994) also compiled information on the requirements for various roundwood products, shown in Table 1.

Table 1. Summary of requirements for various roundwood products (After: Carpenter, 1994).

	1/4 round	**Fence Posts 1/2 round**	**round**
Species	*Pinus* spp.	*Pinus* spp.	*Pinus* spp.
Lengths (m)	1.5-3.0	1.5-3.0	1.5-3.6
Diameter range (mm)	75-150	60-120	75-200
Treatment Hazard Class	H4	H4	H4
Max Single Knot Diameter	20% circumference	20% circumference	20% circumference
Sum of Knots/Whorls	33% circumference	33% circumference	33% circumference
Sweep (mm/m)	20	20	20
Number of growth rings	-	10 in 100mm and larger, at the SED	10 in 150mm and larger, at the SED

Also, of interest are the prices of postwood, with data presented here comparing 2020 to 2010.

Table 2. Radiata pine log sales for postwood in dollars per tonne comparing 2020 to 2010, with the latter adjusted for inflation (After: New Zealand Farm Forestry Association, 2020).

$/t	Northern North Island	Central North Island	Southern North Island	Northern South Island	Central South Island	Southern South Island
2020	82 - 95	90 - 100	84 - 94	72 - 90	90 - 100	82 - 93
2010	85 - 91	88 - 94	79 - 91	79 - 98	98 - 116	85 - 91

There has also been literature published that contains some relevant figures using CCA production information. The approximately 165 timber treatment plants in New Zealand were estimated to use 5,000 tonnes of CCA salt equivalent each year to treat around 650,000 m^3 of timber to various treatment levels (Love, 2007; Read, 2003; Rhodes, 2013). This relates to the New Zealand Timber Preservation Council (TPC), with non TPC plants expected to add to this value (Read, 2003). This estimate of treated timber is not exclusively for products used in agricultural and horticultural applications. CCA treated wood is used domestically as decks, garden furniture, playground equipment, landscaping, retaining walls, fences, patios and gazebos mostly based on sawnwood, not roundwood. But it also includes CCA timber used for docks, signposts, utility poles, and agricultural or horticultural posts (Read, 2003). The two latter uses were of interest for this study, but there is no publicly available information on the breakdown of volume used in these products.

Regional variation exists regarding wood quality (Cown & McConchie, 1982), with different silvicultural prescriptions typically required. For instance, when growing radiata pine for poles, a compromise is necessary between maintaining very high stockings to suppress individual tree growth and limit branch development and elevated competitive mortality (Manley & Calderon, 1982). Further regime information was presented by Millen et al. (2018a) regarding the NZDFI durable eucalypt products. This detailed a peeler pole plantation with a high final stocking, a 15 to 20 year rotation and small piece sizes on flat to easy sites. A peeler log/saw log plantation was also suggested with a low final stocking, a 30 to 40 year rotation, large piece sizes on stable but steep sites (Millen et al., 2018a).

Internationally, an estimate of roundwood for both landscape and agriculture exists for Australia (Dunn, 2011), although only for 2000, 2007 and 2010 (Table 3). The values represent the estimated treated softwood volume which increased from 2000 to 2007 and then decreased to 2010. The decrease was attributed to a reduction in demand for agricultural and horticultural posts due to long periods of drought, particularly in the key markets of Victoria and South Australia. Dunn (2011) also noted that fewer vineyards were being established, fewer posts were damaged and some non-wood products entered the market. The distinction between grape sticks/horticultural posts and landscape/fencing rounds was lost in 2010.

Table 3. Estimations of roundwood for agriculture and landscape uses in Australia (After: Dunn, 2011).

Australia Estimated Softwood Volume (m^3)			
	2000	**2007**	**2010**
Grape sticks / Horticultural posts	125,803	270,000	249,000
Landscape and fencing rounds	177,361	215,000	
Total	303,164	485,000	249,000

Dunn (2011) focused primarily on collecting information from experts in different areas of the industry, including growers and building professionals. Estimations were made, while historical and forecast trends were also discussed along with the challenges facing the sector. The approach to use experts in the relevant fields was also adopted in the current study.

Tan (2009) estimated the volume of wood used for wooden poles and cross arms in the New Zealand electricity network at 4,634 m^3 per year using a survey method. He discussed and introduced the survey over the phone and also emailed excel spreadsheets to the relevant persons for data input. A similar approach to data collection was taken in this study, with surveys being a useful method to collect data from forest growers and treatment organisations concerning the agricultural and horticultural treated wood markets. This is described in detail in Chapter 4.

4. DATA AND METHODS OF ANALYSIS

This research used three sources of data to produce independent estimates of the market for treated wood for agricultural and horticultural uses:

1. a use per hectare estimate, based on expert knowledge of the specific end uses
2. a manufacturers' estimate, from roundwood manufacturers and CCA treaters 3. a resource use estimate from a survey of forest growers

4.1. Use per hectare

The market size and subsequent annual demand of treated wood were estimated from the typical use per hectare values for pastoral agriculture, vineyards, kiwifruit and apple orchards. This entailed using the information on producing area in hectares for each system from various sources. This data source was an approximation, with the relevant assumptions noted throughout.

4.1.1. Pastoral agriculture

Sheep and beef, dairy, cropping and deer systems are the major farming systems in New Zealand (Table 4).

Table 4. The producing area of the major farming systems in New Zealand in 2017 (After: Beef + Lamb New Zealand, 2019).

	Producing area (ha)
Sheep & Beef Farming Intensive	2,817,321
Sheep & Beef Farming Extensive	5,947,679
Dairying	2,442,000
Cropping	365,000
Deer Farming	261,000

This information was sourced from Beef + Lamb New Zealand (2019), who produced these statistics in collaboration with Statistics New Zealand for 2017. The only adjustment made to these values was the split of the 8,765,000 total sheep and beef producing hectares into intensive and extensive farming based on the work of Morris (2013), who estimated that 32% of sheep and beef cattle farms are high country, 36% hill country and 32% flat to rolling country. These distinctions were based on topography and elevation (Morris, 2013). For this study, it was assumed that high and hill country were both extensive (68%) and flat to rolling country was intensive (32%). These different producing hectares correspond to different average paddock sizes (Figure 2).

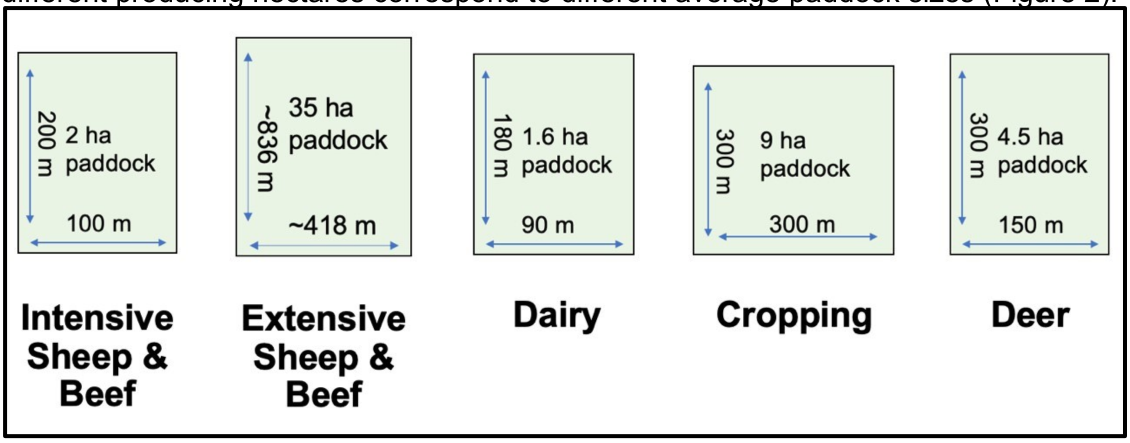

Figure 2. The assumptions of average paddock size, not to scale.

These assumptions were difficult, with paddock subdivision being highly variable, even within districts with fairly uniform soils and farming systems. The sheep and beef average paddock size for intensively farmed areas was determined using existing literature on the subject. Typically, paddock sizes are determined using values such as forage mass and animal weights among other factors (Rayburn, 1992). However, this was more applicable for individual farms with a more general technique suitable in this instance. For sheep farming, the suggested paddock size was 2 ha ("Sheep Grazing", 2018), while beef farming is noted to be quite similar (Glue, 1968). Therefore, to get these approximate estimates, an assumption was made that the average paddock size was 2 ha for intensive sheep and beef farming. The next assumption was that the average paddock for the majority of farms would be rectangular. A 2:1 ratio is preferred because stock walk less in these types of paddocks, minimising soil damage (Clarke, n.d.). These optimum dimensions were therefore assumed to be the standard layout used in New Zealand. Consequently, using the common paddock dimensions with a depth to width ratio of 2:1, the 20,000 m^2 area has a perimeter of 200 m + 200 m + 100 m + 100 m = 600 m.

This assumption of a 2 ha average paddock size was appropriate for intensively farmed sheep and beef land, but was not applicable for extensively farmed land. In consultation with an expert in the field, it was determined that paddock sizes likely ranged from 10 to 60 ha, with an average of 35 ha. The common paddock dimensions with a depth to width ratio of 2:1 have a perimeter of ~836 m + ~836 m + ~418 m + ~418 m = 2,508 m.

The average paddock size for dairy was assumed to be 1.6 ha. This assumption was derived from Glue (1968) and Clarke (n.d.), with the latter noting the appropriateness of a depth to width ratio of 2:1, particularly for cows. The perimeter of this standard dairy paddock was determined as 180 m + 180 m + 90 m + 90 m = 540 m.

The average paddock size for crop farms was difficult to obtain, as there was little literature available about arable farming setups. However, using information from a previous study of 30 farms with 430 paddocks (Mathers, 2014), an estimation of paddock size could be made. An average paddock size for arable farming was assumed to be approximately 9 ha in size resulting in a perimeter of 300 m + 300 m + 300 m + 300 m = 1,200 m using equal sides, with walking stock not being an issue.

The deer farming estimate was made using the same technique as the other estimates. Paddock sizes for deer farming are typically large causing the deer to be more settled and pressure the fence less (Tuckwell, 2003). Therefore, paddock sizes range from 4 to 5 ha (Venison Advisory Service Ltd, 2016). The average value of 4.5 ha was used, with the perimeter being 300 m + 300 m + 150 m + 150 m = 900 m, again assuming the previously used 2:1 depth to width ratio.

An adjacency factor was calculated to account for the paddocks situated beside each other sharing a fence line. Assumptions of average farm sizes were divided by average paddock sizes to determine the number of paddocks for an average farm for each farming system (Table 5). Farm and road infrastructure were also accounted for, allowing the theoretical layouts of farms to be determined.

Table 5. The average farm sizes, average paddock sizes and the number of paddocks for an average farm of the major farming systems in New Zealand (After: Beef + Lamb New Zealand, 2019).

	Average farm size (ha)	Average paddock size (ha)	Number of paddocks for an average farm
Sheep & Beef Farming Intensive	375	2	187
Sheep & Beef Farming Extensive	375	35	11
Dairying	220	1.6	138
Cropping	122	9	14
Deer Farming	333	4.5	74

As the following figures show, the theoretical layouts of the farms based on average values were generalisations of actual farms in New Zealand. In reality, farm sizes vary markedly with factors such as rivers, other farm infrastructure, additional roads and topography forcing highly variable layouts. In this instance, these assumptions were necessary to account for the paddock adjacency effect and the values and overall methods were verified by expert consultants.

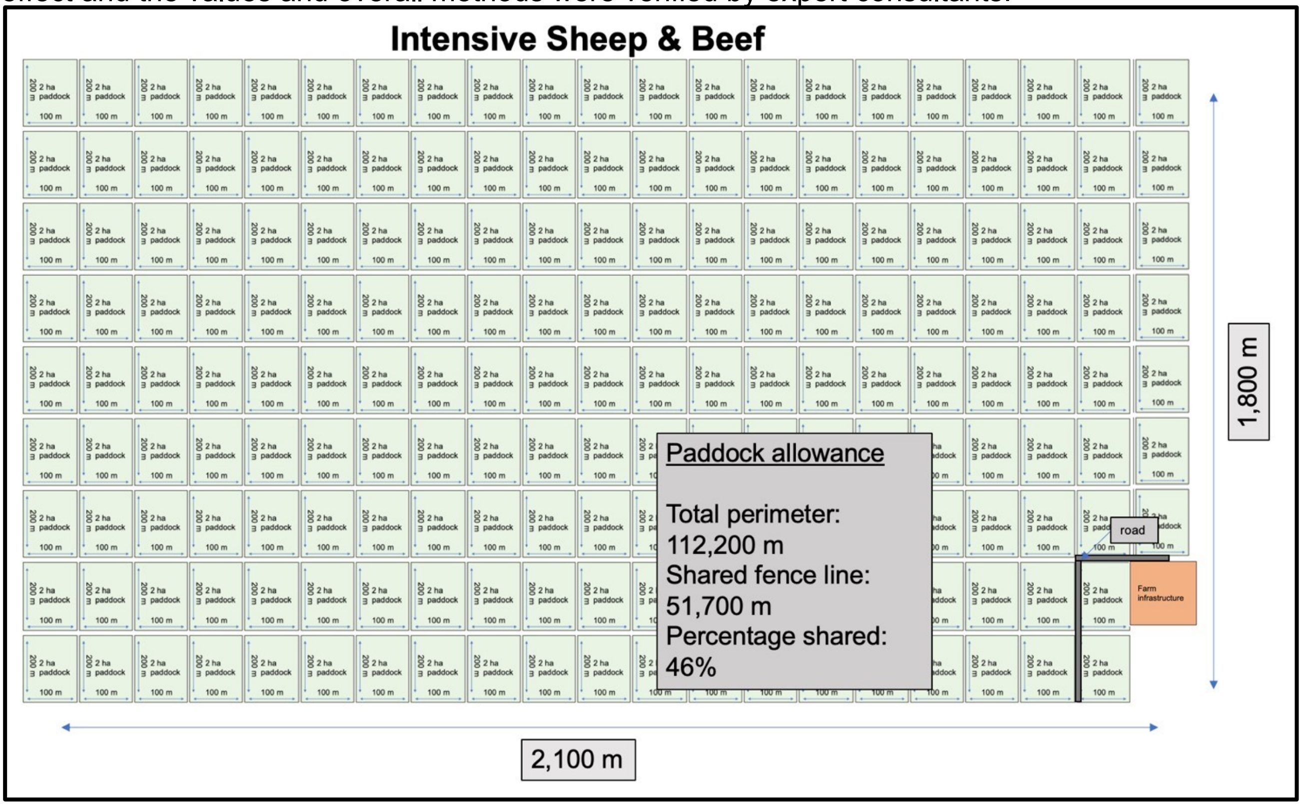

Figure 3. Sheep and beef intensive paddock allowance, not to scale.

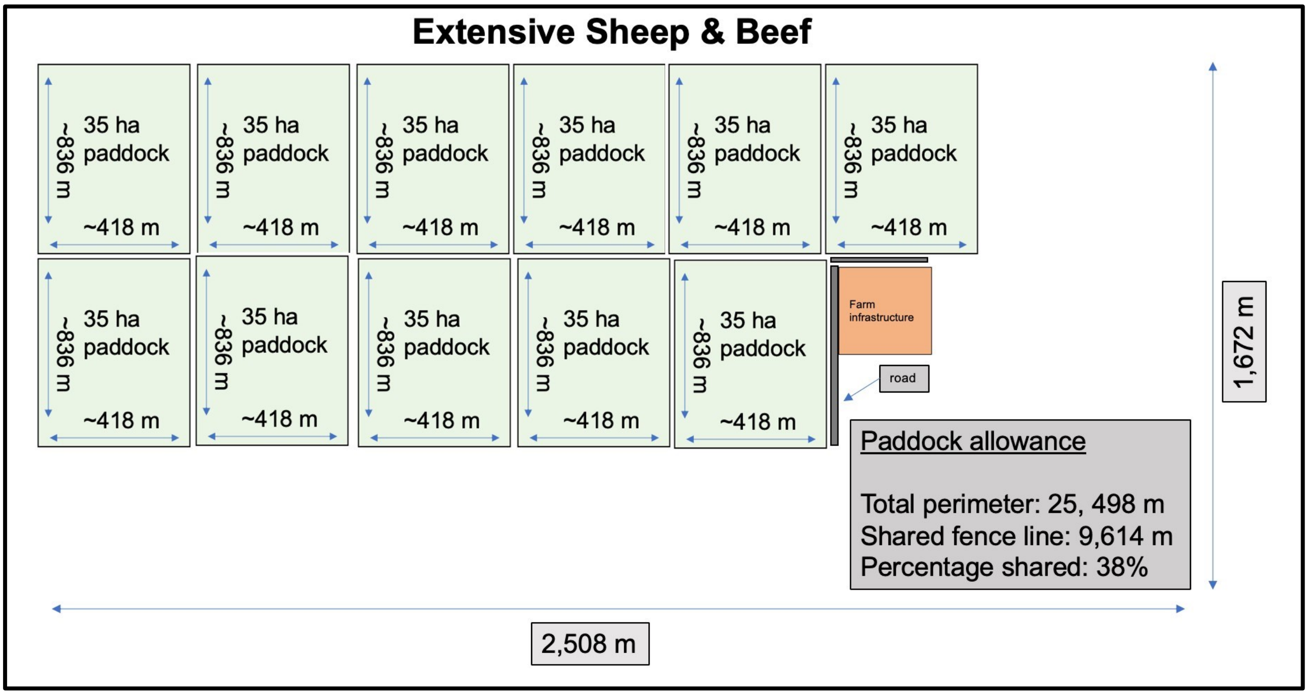

Figure 4. Sheep and beef extensive paddock allowance, not to scale.

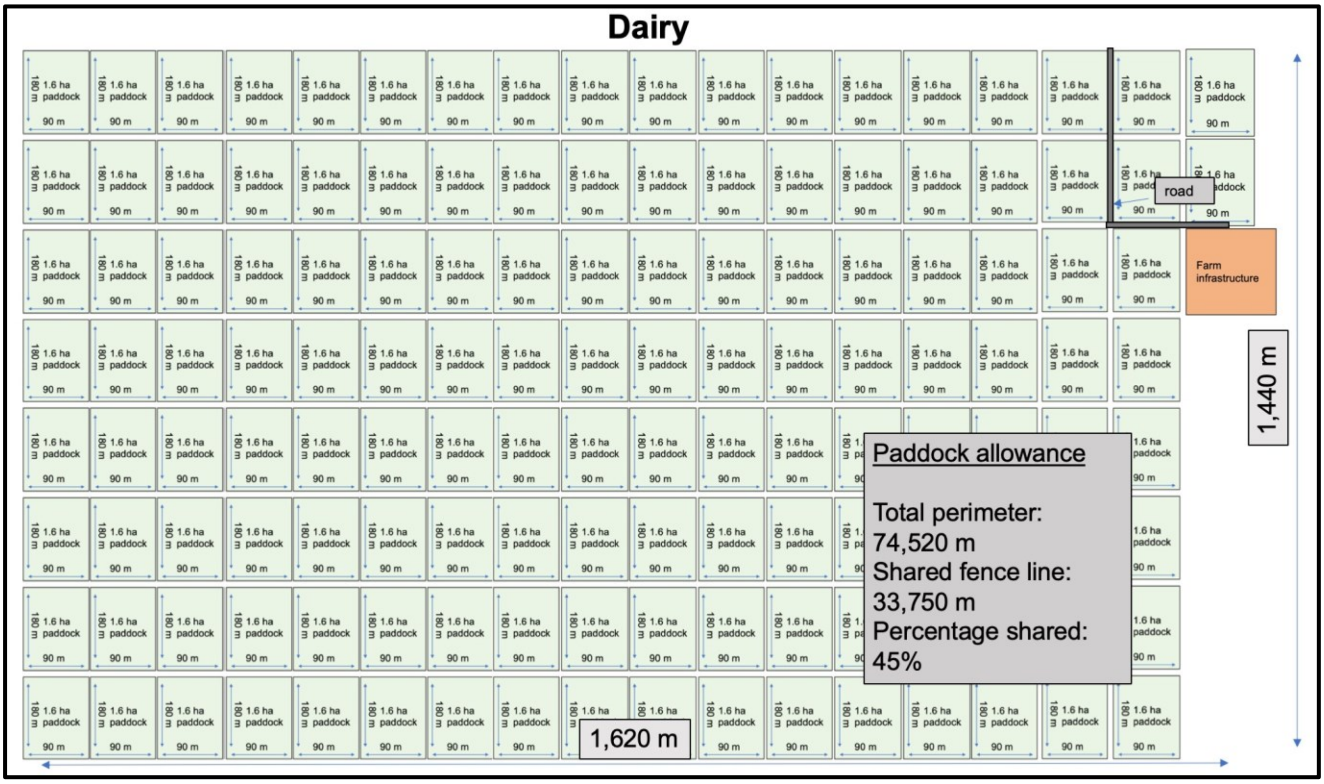

Figure 5. Dairy paddock allowance, not to scale.

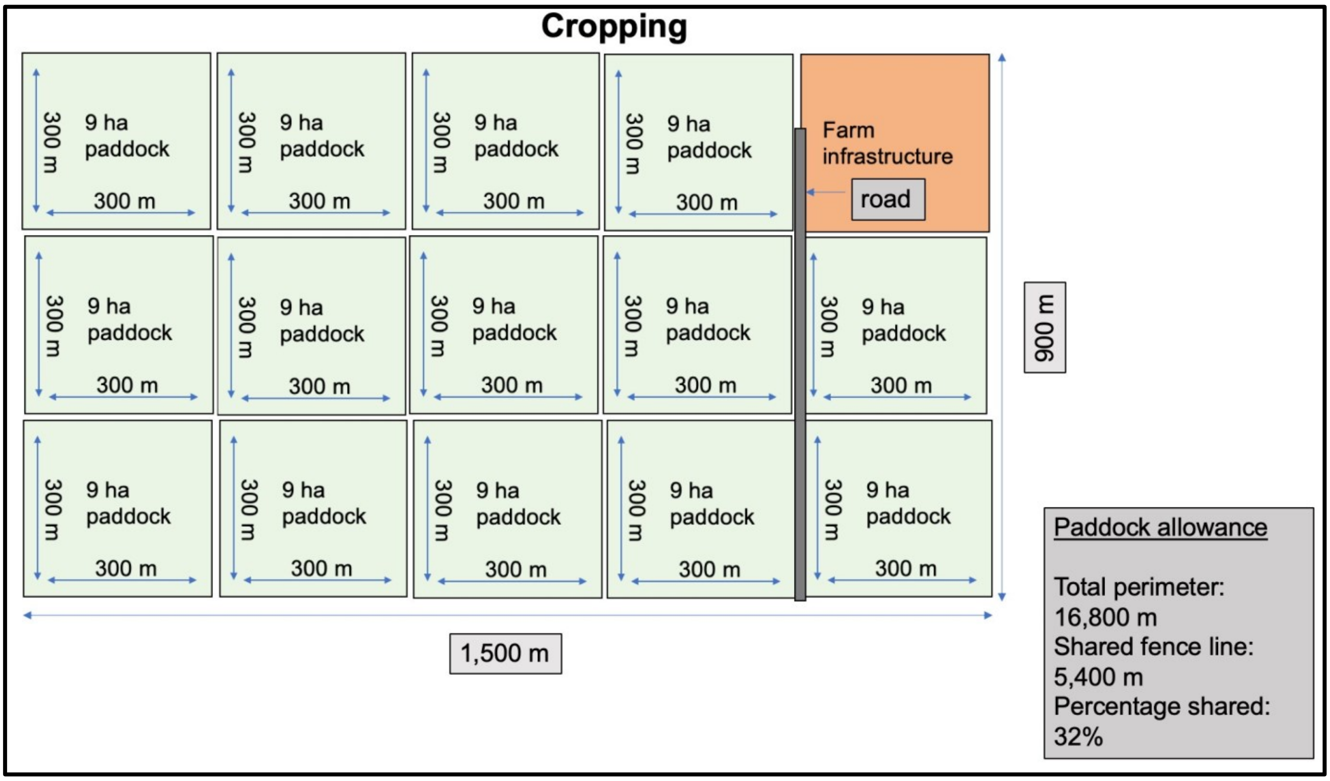

Figure 6. Cropping paddock allowance, not to scale.

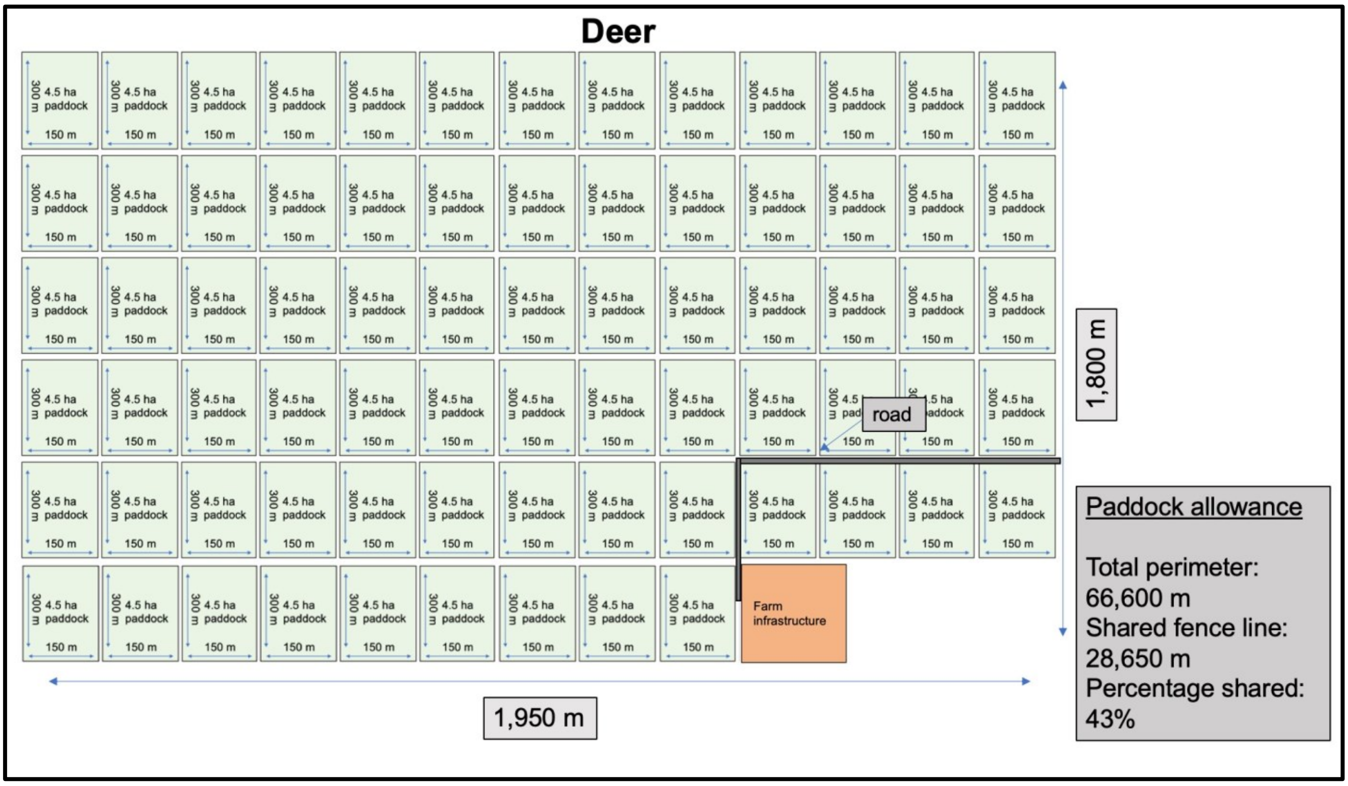

Figure 7. Deer paddock allowance, not to scale.

Other assumptions which had to be made to obtain the volume of posts in the farming systems were the average post spacing and the typical post dimensions. For sheep and beef farming in New Zealand, wire and battens and post and wire fence types are utilised with spacing ranging from 4 to 5 m and 2.5 to 5 m, respectively (Taratahi Agricultural Training Centre, 2016). An average value of 4.5 m between posts was used for the calculations.

Dairy farming in New Zealand utilises wire and battens and post and wire fence types (Taratahi Agricultural Training Centre, 2016). The post spacing differs between these types with wire and batten post spacing being 4 to 5 m and post and wire being 5 to 12 m. An average of these values was calculated as 6.5 m between posts. For the cropping estimate, fence posts can have wider spacing between them as no livestock needs to be contained (Taratahi Agricultural Training Centre, 2016). In this case, 10 m spacing was assumed. For deer farming, post spacing ranges from 5 to 6 m (Venison Advisory Service Ltd, 2016), so an average of 5.5 m was assumed.

As there was little available information on typical post dimensions, some standard values and calculations were used. Dairy farming, sheep and beef farming and crop farming all use standard dimensions of posts (Taratahi Agricultural Training Centre, 2016). Therefore, a standard length of 1.8 m for these three agricultural fence types and an average diameter of round, half round and quarter round fence posts of 0.133 m was assumed. Assuming a cylindrical product, a volume of 0.025 m^3 for one post was determined. Deer farming has a fence height of 1.95 m (Venison Advisory Service Ltd, 2016), while an additional 1 m is below ground. Assuming the same diameter of 0.133 m, the volume of one deer fence post was 0.041 m^3.

Figure 8 shows the step by step process of achieving the agricultural estimate, with different values used for each of the farming systems.

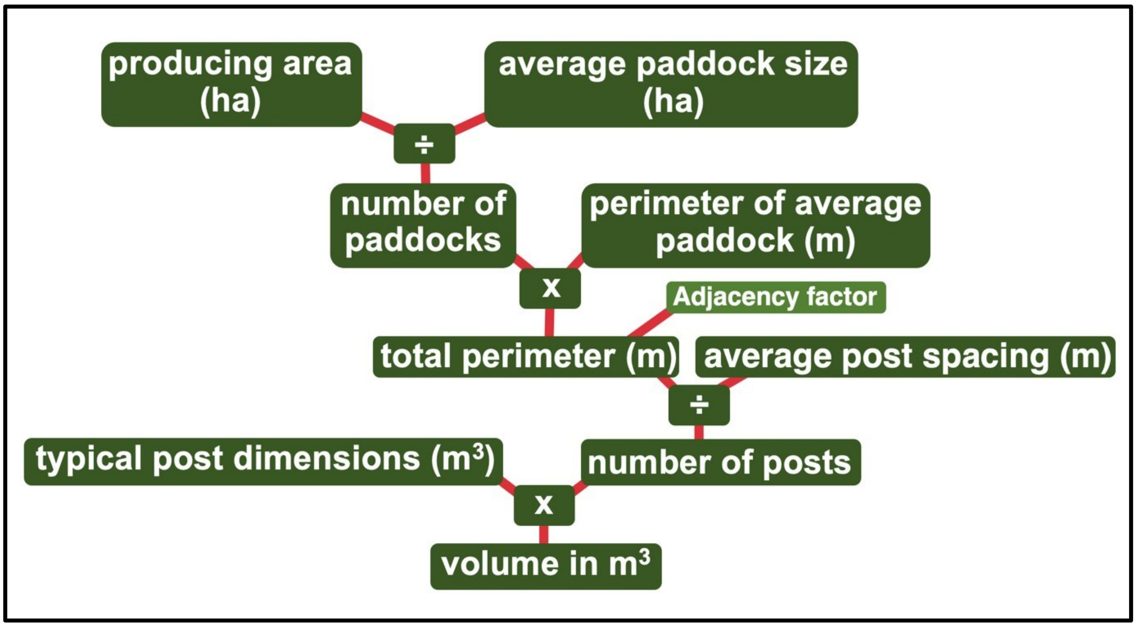

Figure 8. Step by step process of the calculation process for the pastoral estimate of volume of posts.

A replacement cycle of 25 years, corresponding to a replacement rate of 4% was determined for agriculture based on expert consultant feedback. The expansion values were determined based on historical growth for each of the farming systems based on data from Beef + Lamb New Zealand (2018) and Beef + Lamb New Zealand (2019), in collaboration with Statistics New Zealand. To determine the expansion, values from 2012 and 2017 were compared, with the only increase present in dairy and crop farming. These values can be seen in Appendix 2.

4.1.2. Vineyards

The New Zealand Winegrowers (2019) Vineyard Register Report provided data on the area of wine producing land in twelve of the sixteen regions of New Zealand and provided average sizes of vineyards, as seen in Appendix 3. Then, using the assumption that vineyards utilise posts at 579 posts per hectare (Robinson et al., 2006), an estimate of posts currently in vineyards could be determined. The volume was determined using the work of Orton and Evison (2009), seen in Table 6.

Table 6. The average volume of roundwood used by vineyards (Source: Orton & Evison, 2009).

Product	Volume (m^3/ha)	Percentage of total
Intermediates	10.31	77%
Strainers	2.42	18%
Stays	0.48	4%
Blocks	0.11	1%
Total	13.31	

The replacement rate was assumed to be 4% based on research by Robinson et al. (2006), while expansion was projected at 474 ha in 2020 and 347 ha in 2021 (New Zealand Winegrowers, 2019), with an average of 411 ha.

4.1.3. Kiwifruit

The kiwifruit sector estimation of posts per hectare needed to be determined, as no paper had reported a specific value as was the case with vineyards. Conveniently, McAneney et al. (1984) reported that the spacing for the T-bar configuration is 5.5 m between supporting structures along rows spaced 5 m apart. However, the pergola configuration has been favoured as it achieves greater yields and has replaced the T-bar configuration as the most common kiwifruit structure (New Zealand Kiwifruit Growers, 2018). For that reason, an average was determined from the values provided by Campbell and Haggerty (2008), which was a range from 3 to 5 m for rows and 5 to 6 m spacing between rows. The average value for the posts per hectare calculated was 455 posts per hectare. However, an industry expert indicated that the value could be as high as 546 posts per hectare. An average value of 501 posts per hectare was therefore used.

Using the assumption for the usage of 501 CCA treated posts per hectare, the number of posts used by the kiwifruit industry was estimated making use of the producing area (Appendix 4) given by New Zealand Kiwifruit Growers (2018).

A combination of different sources was required to determine the volume per hectare value. Strik and Cahn (2000) noted that the pergola system utilises 6-foot posts, which equals 1.83 m. A typical configuration for pergola systems can be seen in Figure 9.

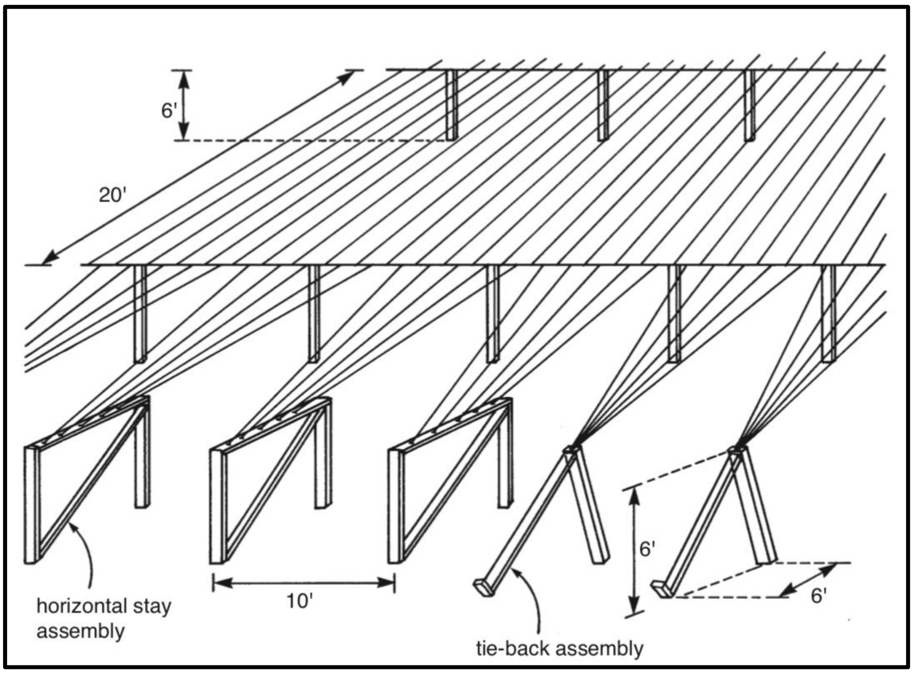

Figure 9. Pergola trellis system for growing kiwifruit (Source: Strik & Cahn, 2000).

Sale (1981) indicated that the posts used are 15 cm in diameter. Using the formula for the volume of a cylinder and values of 0.075 m for radius and 2.8 m for length, a volume of 0.049 m^3 was determined for one post. Assuming 501 posts per hectare, the volume per hectare was 25 m^3.

With no published replacement rate, industry experts were consulted, who indicated 0.5 to 1% per year was a fair assumption. This study assumed an annual replacement rate of 0.75%. Based on the historical growth in the industry, it can be expected that approximately 250 ha of land will become kiwifruit production per year (New Zealand Horticulture, 2017).

4.1.4. Apple

The apple industry estimate involved a consultation process with experts in the industry, as there was very little publicly available information. These experts indicated that the industry average for spacing of posts in rows is 3.5 m, with rows placed 9 m apart, resulting in 317 posts per hectare. New Zealand Apples and Pears (2019) estimated the industry at 10,819 ha, with the experts noting that approximately 25% of this area use these standard spacings, equalling 2,547 ha. The rest of the industry is made up of mature apple trees, which do not require supporting structures.

For the volume calculation, the standard industry height of 4.2 m posts with a diameter of 15 cm resulted in the estimation of one post with a volume of 0.073 m^3 representing a volume per hectare of 23 m^3.

The experts estimated that the replacement cycle in the apple industry was 35 years or 3% per year and expansion at 300 ha per year.

4.1.5. Organic sector

New Zealand Kiwifruit Growers (2018) reported that 165 kiwifruit orchards in New Zealand were organic, representing 480 ha. Approximately 7% of New Zealand’s vineyard producing area was organic (New Zealand Wine, 2016). Organics Aotearoa New Zealand (2018) provided a value for the total organic livestock producing area in New Zealand which referred to dairy as well as sheep and beef farming. These values were displayed in Table 7. The same methods as those outlined above were employed to determine the number and volume of posts.

Table 7. The organic area for vineyards, kiwifruit orchards and livestock farms in New Zealand.

	Organic area (ha)
Vineyards	2,665
Kiwifruit	480
Livestock	64,278
Total	67,423

4.2. Manufacturers

An annual volume for agricultural and horticultural uses was determined by consulting CCA treatment organisations. This method was conducted through phone calls and email correspondence.

4.3. Forest growers

The estimate from forest growers was determined from a survey of forestry companies, with several questions asked over the phone and through email correspondence. The main piece of data requested was the annual volume of supply, while the log requirements in terms of specifications related to the silvicultural prescription and the drivers of production were also collected. Price ranges to compare with existing information and the established markets for small-dimension logs were also collected. The survey sent to the forestry companies can be seen in Appendix 5. Using the survey results of annual volume, a pro-rata approach was utilised to estimate the market, as not all companies responded to survey requests.

5. RESULTS AND DISCUSSION

5.1. Use per hectare

5.1.1. Pastoral agriculture

The pastoral agriculture table shows the step by step process outlined in Figure 8.

Table 8. Values used for calculating the volume of posts for each of the farming systems according to the procedure outlined in Figure 8.

	Sheep & Beef Intensive	**Sheep & Beef Extensive**	**Dairy**	**Cropping**	**Deer**
Producing area (ha)	2,817,321	5,947,679	2,442,000	365,000	261,000
Average paddock size (ha)	2	35	1.6	9	4.5
Number of paddocks	1,408,661	169,934	1,526,250	40,556	58,000
Perimeter of average paddock (m)	600	2,508	540	1,200	900
Adjacency factor	46%	38%	45%	32%	43%
Total perimeter (m)	455,743,173	264,240,065	450,907,337	33,023,810	29,744,595
Average post spacing (m)	4.5	4.5	6.5	10	5.5
Number of posts	101,276,261	58,720,014	69,370,360	3,302,381	5,408,108
Typical post dimensions (m^3)	0.025	0.025	0.025	0.025	0.041
Volume in m^3	2,531,907	1,468,000	1,734,259	82,560	221,732

5.1.2. Total size and annual market demand

The use per hectare method estimates for the vineyard, kiwifruit, apple and pastoral sectors were displayed in Table 9.

Table 9. Total volume of posts for the different sectors.

	Volume (m^3)
Vineyard	506,752
Kiwifruit	311,265
Apple	58,946
Pastoral	6,038,458
Total	6,915,421

The pastoral systems accounted for 87% of the total volume of approximately 6.9 million m^3. Vineyards was next largest at 7%, while the kiwifruit and apple industries were smaller at 5% and 1%, respectively. Of the horticultural sector, vineyards made up 58% of the approximately 880,000 m^3 and kiwifruit orchards accounted for 35%.

Annual market demand was determined based on expansion and replacement rates of the different sectors. These were displayed in Table 10.

Table 10. Annual market demand volume estimations.

	Replacement rate (per year)	Expansion (ha per year)	Replacement (m^3 per year)	Expansion (m^3 per year)	Total (m^3 per year)
Vineyards	4%	411	20,270	5,464	25,734
Kiwifruit	0.75%	250	2,334	6,131	8,466
Apple	3%	300	1,684	6,942	8,626
Pastoral	4%	21,600	241,538	7,499	249,038
Total			265,827	26,036	291,863

The data highlights that pastoral farming and vineyards were the major contributors to the total annual market demand. Annual replacement accounts for 91% of the annual volume, with most of this from the pastoral sectors. The number to note here is the ~290,000 m^3 per year of posts used in the agricultural and horticultural industries.

5.1.3. Organic sector

The organic sector total volume was estimated for vineyards, kiwifruit orchards and livestock farms (Table 11).

Table 11. The organic sector volume of posts for vineyards, kiwifruit orchards and livestock farms in New Zealand.

Type	Volume (m^3)
Vineyards	35,471
Kiwifruit	7,688
Livestock	92,521
Total	135,680

Based on the expansion and replacement rates of the total sectors, the organic sector consumption of treated wood each year was estimated (Table 12).

Table 12. Estimated annual market demand of posts for the organic sector based on replacement and expansion rates of the overall sectors.

	Replacement (m^3 per year)	**Expansion (m^3 per year)**	**Total (m^3 per year)**
Vineyards	1,419	382	1,801
Kiwifruit	58	151	209
Livestock	3,701	116	3,817
Total	5,177	649	5,826

Organic livestock accounted for 66% of the total estimate of almost 6,000 m^3 per year, while vineyards were 31%. Almost 90% of the total was from replacement of posts. It must be noted that the organic expansion was based on that of the total area. Therefore, the numbers presented are a more conservative approach. Organics Aotearoa New Zealand (2018) reported larger expansion figures reflecting an overall trend to shift to organic farming. These were presented in Table 13, with average annual expansion rates for horticulture of 4% and livestock of 8%.

Table 13. Estimated annual market demand of posts for the organic sector based on increasing popularity of organic farming.

	Replacement (m^3 per year)	**Expansion (m^3 per year)**	**Total (m^3 per year)**
Vineyards	1,419	1,368	2,787
Kiwifruit	58	297	354
Livestock	3,701	7,446	11,147
Total	5,177	9,110	14,288

The total annual volume of approximately 14,000 m^3 per year was notably more than the 6,000 m^3 per year conservative estimate. These values are relevant for the NZDFI eucalypt species which have good properties such as hardness and natural durability (Grealy, 2008). This wood is suitable in moderate to high decaying situations for applications such as fence posts (Page & Singh, 2014). The wine growing industry has reported its frustration with treated posts, highlighting issues such as breakage and hazardous waste as major drawbacks of CCA treated radiata pine timber. The organic winegrowers have also expressed their concern with treated posts and accept durable eucalypts as a viable alternative (Millen et al., 2018b). Eucalypt species appear to be a good alternative to CCA treated radiata pine and other preservative treatments (Apiolaza et al., 2011). The annual demand of between 6,000 m^3 (Table 12) and 14,000 m^3 (Table 13) for the organic sectors is therefore relevant for the NZDFI.

5.1.4. CCA liability

CCA treated wood cannot be burned and is instead disposed of in secure landfills, wellcontrolled incineration facilities or is stored at the end of its service life. Considering that there may be 6.9 million m^3 (Table 9) of CCA treated timber existing currently in agricultural and horticultural systems, disposal methods are pertinent. For instance, in the Marlborough region, which is New Zealand’s largest wine region accounting for two thirds of the wine growing in New Zealand (New Zealand Winegrowers, 2019), this issue is being addressed by the Marlborough District Council. McNeil, a Council solid waste manager stated that the region sent 8,000 tonnes of treated and untreated timber to landfill each year (Mcphee, 2016). A hi-tech timber recycling plant is proposed, turning both treated and untreated timber into a charcoal product which is to be processed and sold locally or overseas as carbon black. The Council estimates that this will bring in approximately $90,000 per year. However, there has been some negative response to the proposal, with 105 people or organisations submitting against the resource consent. This includes the Nelson Marlborough Public Health Service and an environmental health agency, with the issue being the proposed location in very close proximity to homes and vineyards (Eder, 2018).

Vogeler et al. (2005) indicated that long term management options of CCA treated timber must be explored. This also relates to product stewardship helping reduce the impact of manufactured products on the environment by having a circular economy (Ministry for the Environment, 2018). The significant liability of CCA treated wood may require Government policy. Interestingly, the use of CCA treated wood in New Zealand is expected to continue to increase because of land intensification (Millen et al., 2018b). Overseas, CCA manufacture is being more heavily regulated by national and international standards such as AWPA P2310 for the United States of America and SANS 673 for South Africa (Millen et al., 2009). This has seen a transition from CCA to other preservatives such as alkaline copper quaternary and copper azole (Dunn, 2011). But, these are likely not long-term solutions as they are less effective and there has been some consumer resistance to the use of chemical wood preservatives.

5.1.5. Alternatives to treated wood

Treated wood is the predominant product in the agricultural and horticultural markets. Alternatives to treated posts are steel, concrete, aluminium and plastic posts. Little data exists around these alternatives, but experts indicate that these products make up a relatively small percentage of the products in these industries. Wood is a more environmentally friendly product in terms of carbon dioxide emissions compared to steel, concrete, aluminium and plastic (Grealy, 2008), so has been preferred.

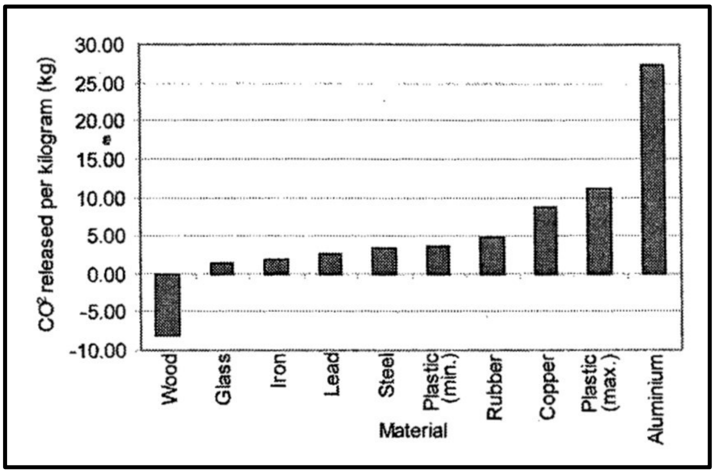

Figure 10. Carbon Dioxide released during the manufacture of one kilogram of the different materials (Source: Grealy, 2008).

5.2. Manufacturers

Two organisations of CCA treated post manufacturers were surveyed for production data. The New Zealand Timber Preservation Council Inc estimated that the annual treated roundwood production for horticultural and agricultural uses is approximately 310,000 m^3, made up of:

- H4: 300,000 m^3
- H5: <10,000 m^3

These estimates were based on internal sources relating to known preservative usage and some individual company data. Hazard class 4 (H4) refers to timber being used in high decay areas such as ground contact or fresh water. The timber is typically used for fence posts and landscaping timbers. H5 timber is used in situations where severe decay may occur such as ground contact with prolonged wetting. This timber is typically used for house piles and poles, retaining walls and horticultural supporting structures.

Koppers Performance Chemicals New Zealand estimated that half of the CCA chemical sold in NZ goes into rural applications (roundwood), equating somewhere between 270,000 m^3 and 300,000 m^3 of product being produced per year. Both independent estimates were reasonably similar, giving some confidence that the market appears to be around 300,000 m^3 per year.

5.3. Forest growers

5.3.1. Pro-rata approach

Surveys were sent to sixteen forestry companies across the regions of New Zealand and eleven responded. This survey method accounted for 53% of the total plantation forest area, although a targeted approach of forestry companies likely to produce roundwood was employed. A pro-rata approach was used to account for the non-responders (Ehrlich, 1985). Volume of wood for agricultural and horticultural uses in m^3 was provided in the survey responses, while hectare values were sourced from Forest Owners Association (2018) and survey responders. These values were graphed and a linear line was plotted (Figure 11). The R^2 value for the relationship between roundwood volume and number of hectares was relatively low at 0.32, indicating that there is a small positive linear association.

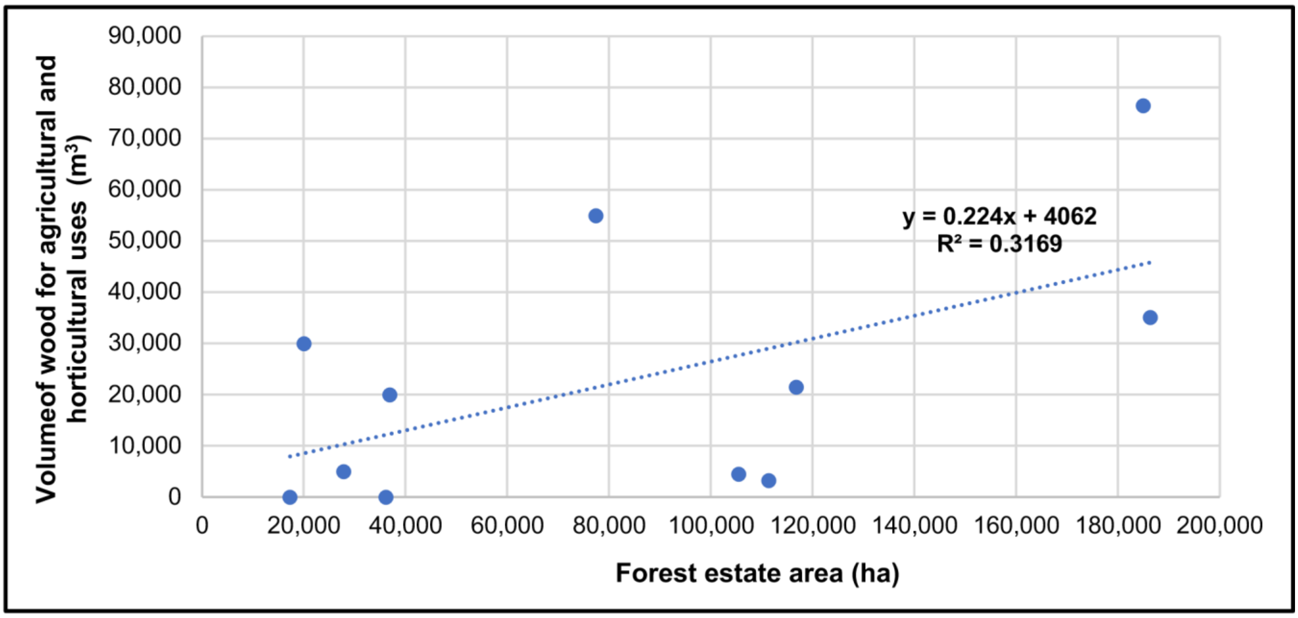

Figure 11. Scatterplot of hectares and volumes from forest grower survey responders for the pro-rata approach.

1,725,476 ha is the net stocked plantation forest area in New Zealand (Forest Owners Association, 2018) and was inputted into the following equation:

$y = 0.224x + 4062$

Where:

y is the volume of posts (m^3)
x is the forest estate area (ha)

This resulted in an estimate of 390,569 m^3 of wood for posts per year, although not all of this will end up in the agricultural and horticultural industries.

5.4. Comparison

The estimates from the use per hectare method, the manufacturers' method and resource use method were relatively similar. This gives confidence in the results of the study.

Table 14. Comparison of the three methods for estimating the agricultural and horticultural annual treated wood market.

	Volume (m^3 per year)
Use per hectare estimate	~290,000
Manufacturers' estimate	~270,000 to ~310,000
Resource use estimate	~390,000

The use per hectare estimate was likely an overestimation as non-wood products such as those mentioned in the alternatives to treated wood section could not be accounted for. However, experts indicate that these products would only represent a small proportion of the market, so were not significant. This method also makes the most assumptions. The resource use estimate is also likely an overestimation, as forest growers indicated that logs could be used for house piles, pulp logs, saw logs and so forth. Differentiation between these products and the agricultural and horticultural products of interest were not possible. Therefore, the conversion of logs to posts is not 100%, with this study estimating a conversion rate of approximately 74% based on the average of the manufacturers' estimate of ~290,000 m^3 per year and the resource use estimate of ~390,000 m^3 per year.

The postwood is likely contained in the small log volume of approximately 1.3 million m^3 removed from plantation forests each year (MPI, 2018), shown in Appendix 6. Using FAO production data, an estimate of 'other industrial roundwood' production was made by MPI (2014) (Table 15).

Table 15. Assumed 'other industrial roundwood' production (Source: MPI, 2014).

	Corrected "Other industrial roundwood" production (m^3)		Corrected "Other industrial roundwood" production (m^3)
1992	320000	2002	400000
1993	320000	2003	400000
1994	320000	2004	400000
1995	320000	2005	400000
1996	320000	2006	400000
1997	320000	2007	400000
1998	320000	2008	400000
1999	320000	2009	400000
2000	380000	2010	400000
2001	400000	2011	400000

This estimate was in the order of the three estimates of this study. The numbers were identical from 1992 to 1999 at 320,000 m^3 and identical from 2001 to 2011 at 400,000 m^3. 'Other industrial roundwood' also contains products outside of the agricultural and horticultural products targeted in this study, as previously mentioned. Carpenter (1994) estimated 312,000 m^3 per year of treated posts and poles in 1986 which is relatively similar to this study's annual market estimate.

Literature based on similar data and methods corresponds with the findings of this study. For instance, the vineyard post replacement of approximately 22,000 m^3 per year (Orton & Evison, 2009) is very close to the value provided by Millen et al. (2009) of 24,000 m^3 per year. This also correlates with this study's estimate of 20,270 m^3 being replaced annually at a replacement rate of 4% (Robinson et al., 2006). As such, this indicates that the estimate of the total number of posts in vineyards of approximately 22 million is relatively accurate as 4% of this value is 880,000 posts, very close to the replacement rate of 900,000 posts per year produced by Millen et al. (2009).

5.5. Log specifications and postwood log market

The survey queried the log specifications for post manufacturing. These varied between companies, with the response ranges shown (Table 16).

Table 16. The main specifications as indicated by forest grower surveys.

Product description	Length (m)	Small end diameter (cm)	Other
Small industrial log Roundwood Postwood Small sawlog	3.6 to 14	6 to 28	Knot size <7 cm (some cases <12 cm) Sweep 25% of SED No wobble No sapstain Free of disease, rot, fungus, insect infection, dead wood

Some companies also indicated that the products can be split into medium, long and cut to length products. The medium posts were typically between 3 and 9 m, while the long posts were between 10 and 14 m. Cut to length varied between companies, but was relatively short at 3, 4 or 5 m typically. The wholesale price ranges for these log products ranged between $80 to $125 per tonne, with most responders noting an average of $100 per tonne. Appendix 7 shows the prices for the roundwood market in the Central North Island. This was supplied by a survey respondent. The average price for 2019 was approximately $93 per tonne delivered to the mill. One company stated that they pegged their roundwood prices to their KIS and KM market price as those two grades have the same diameter ranges as roundwood. This company also factors in the additional cartage costs onto the price as their roundwood customers are located further than the local port. This ensures that the company is neutral as to whether they sell to the export market or the domestic market.

The majority of the companies source the logs from either industrial or small-scale forests from clearfell operations, with few from thinning operations. It was indicated that production thinning had slowed because the volume is typically not high enough to meet roundwood orders and production thinning viability. Approximately half of the responders indicated that they had long term contracts with manufacturers for the supply of logs. One company noted that they had long standing agreements with several manufacturers, but the actual volume that they get depends on the availability from blocks they are clearfelling and the manufacturers demand. The former refers to material coming mostly from blocks that have a reasonably tight stocking, with the company noting that the majority of their pruned blocks do not produce this type of material. The company noted that the majority of the time the demand outweighs the supply. A few companies stated that although they did not have long term supply contracts, they did have long term supply relationships with manufacturers. The contracts are standard quarterly sale and purchase agreements whereby product, specification, volume and price are negotiated quarterly. One company noted a supply contract period of more than five years, with a roundwood manufacturing plant being in close vicinity to its forests. A forestry management company stated that they had no long-term contracts with manufacturers as they focus more on getting the best value for their forest growers. Another company noted that the supply and contract were dependent on the timing of their thinning program.

Responders were also asked to indicate the markets that exist for small dimension logs. All responders noted both the export and domestic pulp markets, while some noted chipwood, biofuel and firewood as markets. One company also noted small dimension logs being used for packaging and furniture. Another company indicated that logs could be peeled for plywood, while most also indicated small sawlogs for export. Interestingly, only two companies indicated the agricultural and horticultural markets.

The companies that do not supply roundwood typically find that the specifications for KIS grade export logs are easier to meet than the specifications for roundwood with the premium for cutting roundwood not justifying the additional handling by crews. Furthermore, with high export prices in recent times, areas close to the port generally do not cut roundwood. As Table 17 confirms, the lower quality KIS grade averaged approximately $80 per tonne and the higher quality K grade averaged almost $99 per tonne.

Table 17. Wharfgate log price range delivered to wharf (Source: AgriHQ, 2020).

$/t	K	KIS
North Island	101 - 104	82 -85
South Island	94 - 95	75 - 77

Some of these companies noted higher logging rates had to be paid to crews for them to produce roundwood. The roundwood specifications are quite strict, with some companies struggling to meet the requirements. The attractive export prices provide a clear indication as to why not all companies supply the market. One company stated that they have trees with high taper that are pruned. Anecdotally, they found that the larger piece sizes from pruned stands create more breakage at the top of the tree, resulting in less roundwood being recovered.
All of the companies supplying roundwood used radiata pine, with one company indicating that they were trialling *Eucalyptus botryoides* and *Eucalyptus saligna* for vineyards who did not want treated wood. They indicated that there was a potential market in that area.

Based on the survey responses, the majority of the roundwood volume was concentrated in Northland, the Central North Island (CNI) and Nelson. This is logical considering these areas typically have less taper, smaller branches and low to moderate soil fertility (New Zealand Soil Bureau, 1968; Rigg, 1954; Roberts et al., 1996). These findings align with the work done regarding post and pole regimes, particularly the regional variability (Cown & McConchie, 1982).

Reflecting on the comments by Spinelli et al. (2018) who noted that companies can significantly increase the value of their small logs if they sell them as posts for agricultural and horticultural uses, the findings here do not align exactly. Spinelli et al. (2018) investigated durable chestnut wood which is likely the cause of the difference. The statement may be relevant to companies in the regions mentioned above, with other companies favouring K grade and pulp export grades. Roundwood is, therefore, more important in those regions and of lesser importance in other areas, specifically those close to ports.

5.6. The supply chain for treated roundwood

According to experts, the typical flow of the products of interest for agricultural and horticultural uses is shown in Figure 12. From the forest, the next stage is either the post processor/treatment plant or a post processor alone. Licensing and certification are required when using treatment chemicals, with this leading to the different pathways observed. Finished products either go via a retailer or directly to the customer.

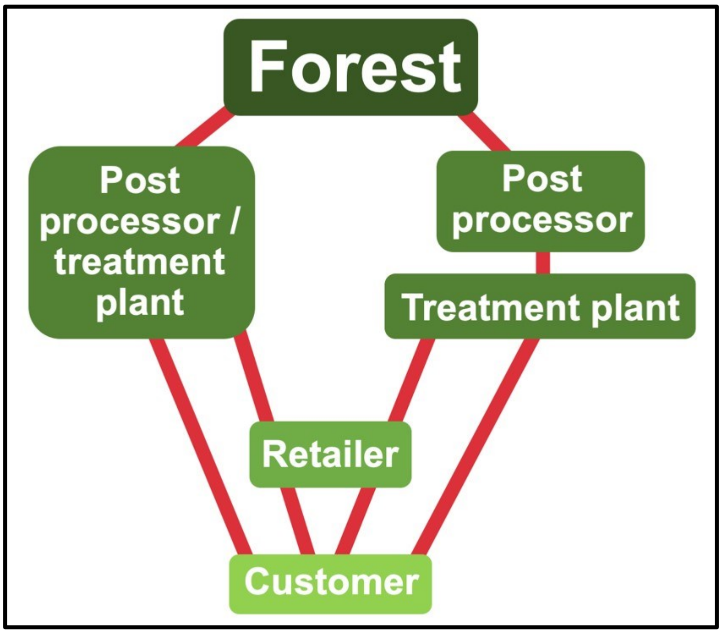

Figure 12. Flowchart of agricultural and horticultural products from the forest to the customer.

6. AREAS FOR FURTHER STUDY

There are certain aspects of this topic that deserve further research. A more thorough review of post manufacturers regarding their connection with forest growers is necessary. Specifically, the price differential and log specifications. The NZDFI should expand on the work presented here with a feasibility study regarding the agricultural and horticultural markets for naturally durable wood. This work could involve estimating the area required for eucalypt plantations, specific regimes and post performance. More accurate estimates may be possible if future studies can account for alternative post products and get more succinct data from the surveys of forest growers. Future studies should verify the impact of farm riparian area fencing on the estimates. It would also be relevant to further explore the expansion of the organic and horticultural sectors, potentially through surveys of these industries. Further work should be completed regarding the disposal methods of the CCA treated wood, with policy potentially necessary to regulate this.

7. CONCLUSION

The treated wood market for agricultural and horticultural uses in NZ has been analysed using three independent methods to estimate the size of the market. These three methods were a use per hectare estimate, a manufacturers' estimate and a resource use estimate.

The use per hectare method estimated a total of approximately 6.9 million m^3 of CCA treated wood currently in use in the agricultural and horticultural industries. Annual market demand was determined using sector expansion figures and replacement rates, determining approximately 290,000 m^3 per year of CCA treated wood used in these industries.
Consulting two independent CCA organisations provided estimates of approximately 310,000 m^3 per year and 270,000 m^3 to 300,000 m^3 per year. The resource use estimate of approximately 390,000 m^3 per year was based on forest grower surveys. The values are reasonably similar. This increases the confidence that the size of the market is between approximately 270,000 m^3 to 390,000 m^3 per year. However, the use per hectare estimate may be a slight overestimation, as

this study was unable to account for the non-wood products such as plastic and metal posts. Although, this is not of utmost importance, as experts indicate that non-wood products likely only make up a small proportion of the total market. This method may also be the least precise due to the numerous assumptions involved. The resource use estimate is also likely an overestimation, as the surveys by forest growers indicated that house piles, pulp logs, saw logs and even in some instances, firewood volumes were included, with differentiation between these products not possible. Manufacturing losses also account for the overestimation. A more rational estimate of the market is therefore between approximately 270,000 m^3 to 310,000 m^3 per year.

An estimate of approximately 6,000 m^3 to 14,000 m^3 per year was made for the organic sector, although the former involves a more conservative expansion rate. These values present the opportunity for the NZDFI alternative eucalypt products, as CCA treated wood is banned in organic systems for replacement and expansion. Future work should involve a feasibility analysis on this specific area of the market.

Based on the forest grower surveys, it was determined that export pulp and K grades were the main competitors for agricultural and horticultural products. This was especially the case for forests near ports, who indicated that the pulp grades were much easier to meet. The requirements for roundwood products are reasonably strict and sometimes the prices do not justify the more difficult log processing. From the forest grower surveys it was also found that the majority of roundwood producers are concentrated in the Nelson, CNI and Northland regions of NZ. This is logical considering these areas are of low fertility and typically produce trees with less taper and smaller branches, benefiting the post manufacturers.

The approximately 6.9 million m^3 of CCA treated wood currently present in the agricultural and horticultural industries presents a significant CCA liability. Proposals such as the Marlborough District Council funded pyrolysis timber recycling plant may be necessary for other parts of NZ. Future policy regarding the disposal of this wood may also be necessary, with further work in this area justified.

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9. APPENDICES

9.1. Appendix 1

Pile of broken CCA posts in a Marlborough vineyard (Source: Millen & Altaner, 2017).

9.2. Appendix 2

Expansion of the major agricultural farming systems in New Zealand, 2012 to 2017 (After: Beef + Lamb New Zealand, 2018; Beef + Lamb New Zealand, 2019).

	2017 area (ha)	2012 area (ha)	Expansion per year (ha)
Sheep & Beef Farming	8,765,000	9,328,000	-112,600
Dairying	2,442,000	2,415,000	5,400
Cropping	365,000	284,000	16,200
Deer Farming	261,000	287,000	-5,200

9.3. Appendix 3

Producing area, number of vineyards and the average area per vineyards for the regions of New Zealand (Source: New Zealand Winegrowers, 2019).

Region	Producing area (ha)	Number of vineyards	Average area (ha) per vineyard
Auckland	313	85	4
Canterbury	157	30	5
Central Otago	1,873	207	9
Gisborne	1,181	69	17
Hawke's Bay	4,678	229	20
Marlborough	26,288	1,060	25
Northland	79	23	3
Nelson	1,162	103	11
Waitaki Valley	58	16	4
Waikato / Bay of Plenty	15	4	4
Waipara Valley	1,300	68	19
Wairarapa	969	125	8
Total	38,073	2,019	19

9.4. Appendix 4

Kiwifruit industry producing area (Source: New Zealand Kiwifruit Growers, 2018).

Region	Area (ha)
Northland	440
Auckland	494
Bay of Plenty	10,238
Waikato	549
Poverty Bay	267
Hawkes Bay	202
Lower North Island	78
South Island	424
Total	12,692

9.5. Appendix 5

Survey of forest growers questions:

Geographical site locations covered in these answers

What are the typical sources of logs for agricultural and horticultural treated wood uses?

Forest type	Thinnings	Clearfell
Industrial forest		
Small-scale owners		
Other (please specify)		

Do you have long term contracts with manufacturers for the supply of logs?

1. What are the log specifications for the main (top five) products (for agricultural and horticultural uses) you produce?

Product description	Length (m)	Small end diameter (cm)	Other (taper, sweep, max branch size etc.)

2. What are the wholesale prices for the main (top five) products (for agricultural and horticultural uses) you produce?

Product description	Wholesale price

3. How much volume (m^3) of roundwood posts do you produce annually by major product type?

Product description	Volume (m^3)	Number

4. What markets exist for small diameter logs?

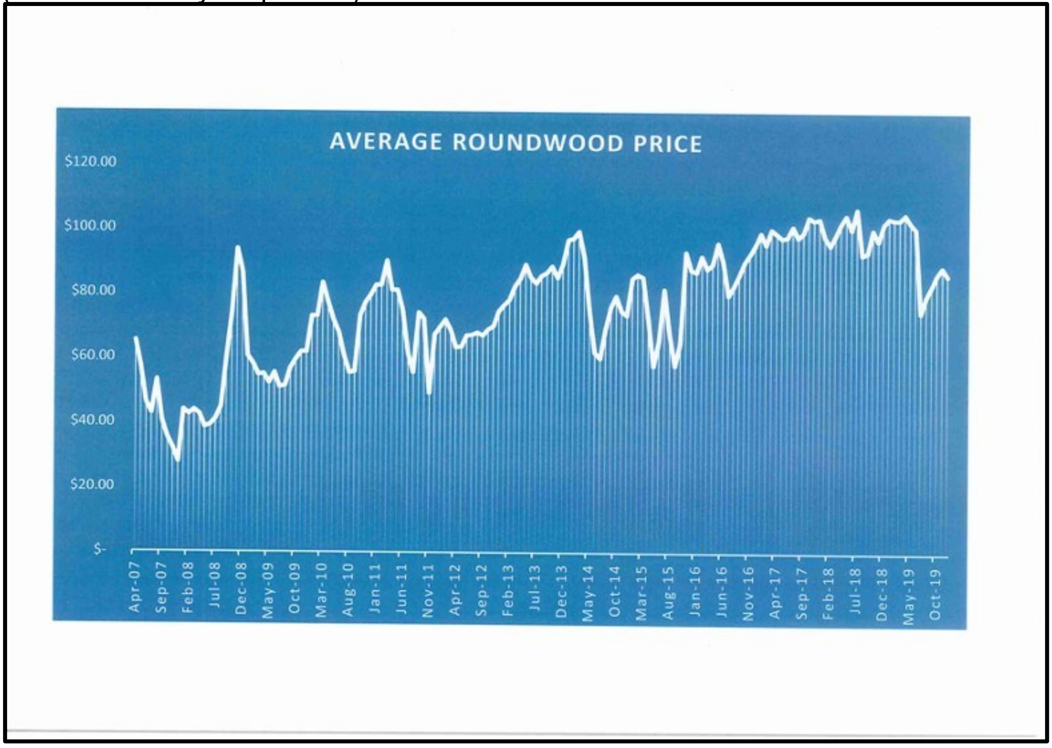
9.6. Appendix 6

Estimated roundwood removals (Source: MPI, 2018).

Year ended	**Removals from planted production forests**		
31 March	**Small logs volume (m^3)**		
1991	1,016,000	**2006**	1,478,000
1992	1,091,000	**2007**	1,408,000
1993	1,136,000	**2008**	1,290,000
1994	1,151,000	**2009**	1,184,000
1995	1,355,000	**2010**	1,180,000
1996	1,268,000	**2011**	1,027,000
1997	1,277,000	**2012**	1,254,000
1998	1,357,000	**2013**	1,277,000
1999	1,373,000	**2014**	1,234,000
2000	1,470,000	**2015**	1,212,000
2001	1,603,000	**2016**	1,334,000
2002	1,479,000	**2017**	1,291,000
2003	1,372,000	**2018**	1,303,000
2004	1,448,000	**Average**	1,267,077
2005	1,486,000		

9.7. Appendix 7

Roundwood prices for the last 12 years to the end of December 2019 for the Central North Island (Source: Survey responder).



ACKNOWLEDGEMENTS

First and foremost I would like to thank my excellent supervisors Dr. David Evison and Dr. Clemens Altaner for their supervision and guidance. This project would not be possible without their help and for that, I thank them wholeheartedly. Secondly, I would like to thank everyone that helped me in any way during the year. People like Paul Millen, Mark Bloomberg, Rob Sheppard and many more provided expert comments at various stages of the project, which was greatly appreciated. Thirdly, I would like to thank all of the rest of my fourth-year class for a great final year and a very enjoyable four years at the School of Forestry. Lastly, I would like to thank my family, particularly my parents Ewout and Liesbeth for their support not just at university, but throughout my whole life. A big thank you must also go to Luis Apiolaza for organising and coordinating the course in challenging circumstances.