Wooden posts – a review

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1. Summary

Roundwood (posts and poles) is an established wood product, making use of smaller diameter logs. Little literature on post production, the market size and value is available. While the New Zealand Dryland Forests Initiative (NZDFI) envisages to establish a naturally durable eucalyptus resource with agricultural posts as a key product, the posts might also be an attractive opportunity for commercial thinnings of plantation spices such as Douglas fir or radiata pine. This report focuses on wooden posts not poles, acknowledging that a continuum between the two, with posts being smaller and typically not used for structural application for which standards apply.

Various machinery for post and pole production is available, ranging from small to large scale production capacity. Quality (e.g. shape) of the posts and production capacity differs between production technologies.

The New Zealand post market is dominated by CCA treated radiata pine with whole sale prices of $NZ 300 to 400 per m^3, comparable to sawn timber. No significant domestic market for naturally durable posts was identified. Overseas, in Europe, Australia and the US, naturally durable posts are traded at a wholesale price of approximately $NZ 700 per m^3; a likely consequence of restrictions in the use of CCA, but also traditional naturally durable products. Option for the production of value added products from posts have also been listed.

In the NZDFI context, the plantation estate under different regimes to sustainably supply logs for a small and large capacity heartwood post production mill has been estimated. Depending on plantation regime, the surveyed wholesale price of heartwood posts were 2 to 5 times higher than the available estimated stumpage costs of the durable eucalypts. The price difference will be need to cover harvesting, processing costs as well as manufacturer profit.

Finally some gaps in the knowledge, warranting more research, are listed.

Contents

2. Background

Little literature on wooden posts exists. The outdoor timber market was reported to represent a third to a half of the sawn and roundwood market in Australia (Dunn 2011). Wooden posts are a significant higher value utilisation option for small dimension stems and have a substantial market in the agricultural sector. There is a continuous transition from producing posts to poles, with the latter being used in construction and needing to comply with specifications in building standards (e.g. NZS3605 (2001), AS/NZS4676 (2000) or AS2209 (1994)). Posts and poles are typically used in ground contact and therefore at risk from fungal decay. Generally durability of wood posts is achieved through the use of naturally durable heartwood (Scheffer and Morrell 1998) or preservative treatments of non-durable timber, which while providing a consistent product are associated with health and disposal problems (Townsend and Solo-Gabriele 2006, Walker 2006). Natural decay resistance varies greatly between timber species and standards have been developed to classify naturally durability of timbers (EN350 (1994) or AS5604 (2005)). If less durable timbers are used, posts will require more frequent replacement or use in less hazardous environments as for example defined in NZS3640 (2003).

The wooden post sector is of interest to the New Zealand forest sector for at least 2 reasons:

- Utilisation of small diameter log resource
  The production of wooden posts utilises small diameter logs for a higher value solid wood product with processing technology from small to large scale available. Wholesale post prices are with NZ$ 300 to 400 per m^3 are comparable to sawn timber (see 10.9). It therefore might be a profitable opportunity for a) commercial thinnings of the current radiata and Douglas-fir (and others alternative species) plantation estate or b) the often considerable amounts of harvesting residues (Visser, Spinelli et al. 2018). It is conceivable that new markets and products could be found for the additionally produced posts.

- Establishing a sustainable naturally durable hardwood resource
  Sustainably produced naturally durable hardwood is a globally scarce resource, often illegally harvested in tropical forests from endangered species (Nellemann 2012). The New Zealand Dry Land Forests Initiative (NZDFI) (Millen, Altaner et al. 2019) is one of the few efforts globally to establish a sustainable plantation resource of naturally ground durable hardwood (Millen 2009). Several markets have been identified, with agricultural posts being central (Millen, Altaner et al. 2018).

3. Market

New Zealand's wooden post market is dominated by CCA treated radiata, of which standard post sizes are traded (10.1 Table 3, Anonymous (2016)). However, little information is available on the market volume. No sizable market for naturally durable timber posts exists in New Zealand.

Demand for alternative agricultural posts exists in New Zealand not only in the organic sector (OANZ 2010), which requires an alternative for CCA treated pine, but also for the agricultural sector in general (Millen 2009, Millen, Altaner et al. 2019). Alternative post products made from steel, concrete and plastic are also available (OANZ 2010). Roundwood demand has been estimated for the New Zealand vineyards (Orton and Evison 2009) and the wooden pole and crossarm demand for New Zealand's electricity network industry (Tan 2009).

NZDFI durable eucalypt species are more than twice as strong than radiata pine (Bootle 2005) and therefore smaller diameter posts could be used for to withstand the same forces. This could in particular be an advantage for vineyards, where machine operation could be facilitated. Mechanically an 80 mm diameter durable heartwood post might be comparable to CCA treated pine No 3 (150 mm) strainer post. This would also make the required log diameters for their production more comparable as the sapwood would need to be added to the post diameter for the heartwood logs.

In Europe a market for naturally durable posts exists. These are traditionally manufactured from coppiced chestnut (*Castanea sativa*), which is native in parts of Europe. The European standard (EN350-2 1994) lists *C. sativa* heartwood as Class 2 (durable). Lower durability implies more frequent replacements of posts in ground contact. The narrow sapwood band (EN350-2 1994), often left at least partly on the posts (see 10.2 Figure 3), allows the utilisation of small diameter logs. Now also plantations grown robina (*Robinia pseudoacacia*), which is exotic to Europe, is used for post products. *R. pseudoacacia* is rated class 1-2 (very durable - durable) and has a very narrow sapwood band (EN350-2 1994, Scheffer and Morrell 1998).

In Australia durable eucalyptus posts and poles were traditionally supplied from natural forests, which are becoming a scarce resource. This has been noted not only by the electricity suppliers (Francis and Norton 2006) and some efforts were made to establish a naturally durable eucalyptus plantation resource (Bush 2011, Lausberg 2019). Some research on post properties from thinnings have been conducted recently (Lambert and Severino 2018).

Naturally durable robinia (native to Northern America) posts are also sold in the US, although no larger producer was found during a limited online research. Other durable species might also be available.

No research in other markets, e.g. in Asia, were conducted.

It is worth noting that, in contrast to New Zealand, in the EU, US and Australia, the use of CCA treated timber is heavily restricted (Read 2003). While other preservatives are available they are not as effective as CCA and, at least in Europe, there is a general perception of naturally durable timber being the superior, safe and eco-friendly product. Organic farmers cannot use CCA treated wood and need an alternative product (OANZ 2010).

3.1. Post prices

For New Zealand, retail prices and assortments for CCA treated pine posts are readily available (for details see 10.9 Table 7). A typical retail price for a 2.4 m long CCA treated pine No 3 strainer post (150 - 174 mm diameter) in Canterbury/New Zealand was $NZ 32 in 2019. Assuming a 50% whole sale price this would be $NZ 6.7 per lineal m or $NZ 380 per m^3. Interestingly the price per m^3 seems to decrease with post volume (for details see 10.9 Figure 22). It is worth noting, that the volumetric post price was in the same order of magnitude as sawn structural CCA treated pine or the average value of NZ export sawn radiata timber ($NZ 470 per m^3) (Millen, van Ballekom et al. 2018), which require larger logs for production.

A limited number of retail prices in Europe, the US and Australia for naturally durable posts made from chestnut, robinia or eucalypts have been gathered (see 10.9 Table 8 for details). Europe appeared to have the most established market and largest businesses. Large price differentials ($NZ/m^3 710 to $NZ/m^3 6200) for similar products between retailers have been noted, but this could partly be explained by some post producers directly selling posts closer to whole sale prices. With an average retail price of to $NZ/m^3 1400 a whole sale price of $NZ/m^3 700 appears to be reasonable. Given the fact that durable eucalypt posts are stronger, smaller diameters could be mechanically comparable to CCA treated pine. Consequently, the piece price for the 2 products would be comparable; $NZ 6.7 and $NZ 7.0 for CCA treated pine (150 mm diameter) and durable eucalypt (80 mm diameter) posts, respectively.

The gathered prices indicated a premium for class 1 ground durable timber compared to class 2 (e.g. *C. sativa*), if individual retailers are considered. But this is unclear if all surveyed retailers are considered due to the large variance between them.

3.2. Value added products

Businesses involved in the naturally durable post market are also mechanically producing and selling fencing (see 10.10 Figure 23 and Figure 24) and planter boxes. Playground equipment made from robina is available (see 10.10 Figure 25). It is worth noting that the first concerns/restrictions regarding the use of CCA treated wood related to playgrounds (Townsend and Solo-Gabriele 2006). Other products made from naturally durable posts could include garden sheds, railing or structural products such as the patented Loggo system (see 10.10 Figure 26).

3.3. Raw material

No extensive research on the log specifications, supply volume and prices for posts has been conducted for this report. Log specifications exist for poles in NZS3605 (2001) in New Zealand.

Apart from size, factors such as stem straightness, taper, branching need to be considered when manufacturing posts. Strength and stiffness are required for structural applications. Sapwood width and treatability are important for non-durable species (EN350-2 1994), while for naturally durable posts sapwood width and heartwood durability need to be considered. Splitting of durable eucalypt ‘box-heart’ posts from commercial thinnings was reported the most common cause for downgrade (Lambert and Severino 2018).

The naturally durable wooden post market in Europe is based on chestnut (*C. sativa*) and robinia (*R. pseudoacacia*). In general chestnut is grown in Southern Europe, France and England, often in coppice regimes (see chestnut coppice, chestnut logs, and disc dedbarcker/peeler, Figure 4 to Figure 6). The robinia plantation resource is mainly located in Central/South-eastern Europe (Vítková, Müllerová et al. 2017). More detailed information might be available and inform New Zealand's development of silivcultural regimes including harvesting, pruning and coppice.

4. Technology for wood post manufacturing

Several processes for producing wooden posts have been developed. They differ in the quality/properties and size of the post, size of the suitable raw material and production capacity. Numerous manufactures have developed equipment for wooden post production at variable scale.

4.1. Post debarking / peelers

Removing the bark is essential if the posts are to be treated with preservatives as bark prevents penetration of the preservative into the wood. Further bark will loosen and be shed quickly once posts are in use. Focusing on peeling the bark, leaving most of the wood behind will result in irregularly shaped posts. However, strength is retained as cutting posts into cylindrical shape will cut across the grain at branch swells, considerable weakening the structure (e.g. NZS 3605 mentions a 25% strength loss).

Posts are typically peeled by rotating around their axis while passing them pressed against a rotating disc with blades attached to its side. Mobile as well a stationary machines are available varying in automation and therefore capacity (see 10.3).

Peeling of poles from larger diameter stems can involve 'rosserhead-like' spiral milling cutter heads or 'draw knifes' (see 10.4).

4.2. Rounding / dowel machines

Rounding machines are available to produce cylindrical posts and poles with smooth surfaces (see 10.5). These only differ in size to machines used for the production of wood dowels.

4.3. Rotary peeling

Spindle-less (round up) lathes have been used for the manufacture of cylindrical posts. They restrict the maximum length of the post to the length of the blade in the lathe, which is typically ~2.4 m. The lathe will not only remove stem taper and growth irregularities, but could also remove sapwood and leave a cylindrical heartwood post of optimised diameter. Chinese built spindle-less lathes are widely used in China for the production of veneers for the plywood industry (Arnold, Xie et al. 2013), but are also available from leading conventional lathe manufactures like Raute (see 10.6). Production appears to be slow compared to spindled lathes, with reports of 250 posts per day (see 10.6 Figure 15; (Lausberg 2019)). This however should be verified.

An alternative, is to use a rotary (spindled or spindle-less) veneer peeling lathe to produce both, quality veneers from the stiff outer sapwood and a cylindrical heartwood post from the peeler core. Spindled lathes can peel a larger diameter log within a few seconds (see 10.6 Figure 16). This might be attractive for larger diameter stems grown for veneer of species with wide sapwood. Typically peeler cores are a low value product sold not only for low quality (strength) posts but also to the pallet/packaging, firewood or particle/MDF board industry. Naturally durable heartwood posts are likely to be a higher value product.

4.4. Sawing

Posts with square or octagonal cross sections can be manufactured in a saw mill. Posts with flat sides can have an advantage when attaching fixings to a post and are safer to transport. Sawmilling technology can convert larger diameter logs into multiple smaller diameter posts. Sawmilling technology for a large range in production volume is available, ranging from low capacity mobile saws to high capacity chipper canter lines.

For a small scale post production option a mobile horizontal bandsaw has been used to cut square heartwood posts from larger diameter durable eucalyptus logs (see 10.7 Figure 18).

An example of high capacity post production business with sawmilling technology is Octowood (in Sweden) which utilise small diameter logs (for details see 10.7 Figure 17).

4.5. Pointing

For some applications posts are pointed. Again several technologies are available (for examples see 10.8). Pyramidal points can be obtained by passing the post-end through a saw at an angle or past a 'peeling disc' (see video of some mobile machines listed in 10.4 Table 4 and Figure 20) as well as with hydraulically driven blades (10.8 Figure 19). For the latter machines cutting 4 sides simultaneously are available. Conical points can be obtained rotating the post against a peeling blade (see 10.8 Figure 21).

5. Production capacity

Post manufacturing equipment spanning from small-scale one person mobile equipment to large scale facilities producing thousands of posts per day is available. The size and finish of the produced posts is also varying depending on the processing technology. In the following, two scenarios for producing heartwood posts are outlined based on Tian (2019).

5.1. Assumptions

In this simple analysis only one product is considered, a 2.4 m long heartwood post of 80 mm diameter, similar to a peeler core. Yield and value of a log resource with variable diameter will improve if a variety of post sizes is included (Tian 2019).

For this study the stem form and dimensions were taken from the typical improved *E. bosistoana* tree as outlined in NZDFI Regional strategy (Millen, Altaner et al. 2019). The sapwood diameter of the unimproved breeding population at age 7 years was reported to be 70 mm (Li, Apiolaza et al. 2018). Posts will shrink due to moisture loss. No radial shrinkage values from green to air-dry have been reported for *E. bosistoana*. Based on the 8.2% tangential shrinkage of *E. bosistoana* from unseasoned to 12% moisture content (AS1720.2 2006) and a typical 2 : 1 ratio between tangential and radial shrinkage (Forest Product Laboratory 2010), 4% radial shrinkage was assumed for this study.

Consequently, the minimum under bark log diameter to produce an 80 mm air-dry *E. bosistoana* heartwood post is 153 mm.

Min log diameter = post diameter / (1 – radial shrinkage) + sapwood diameter

The stem length taking a 0.2 m stump into account with a diameter larger than 153 mm depending on rotation age / DBH was displayed in Figure 1.

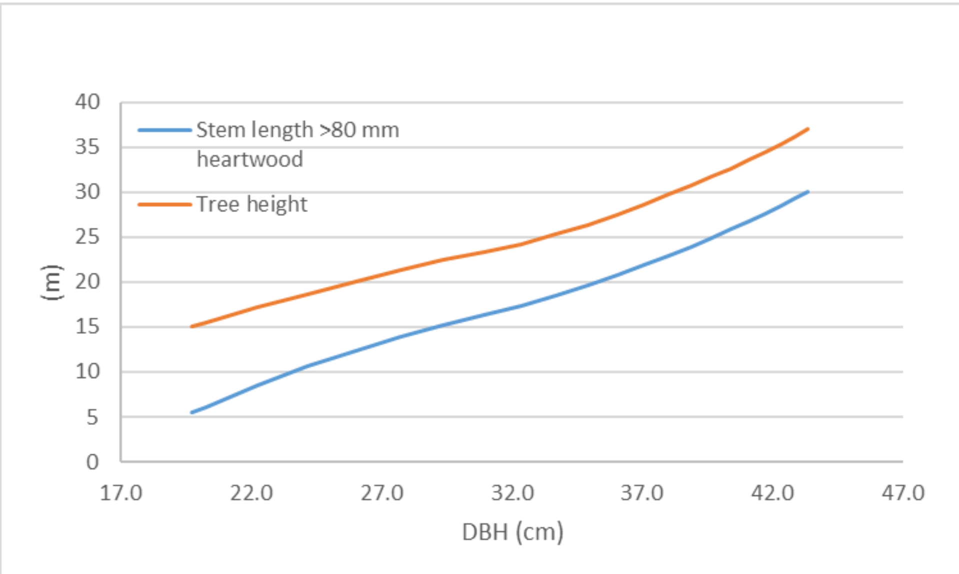

Figure 1: Tree height and stem length with >80 mm heartwood diameter of an improved E. bosistoana tree.

Only smaller trees are needed for the production of small posts (2.4 m length; 80 mm diameter). These could be sourced from short rotation post regimes or commercial thinnings of a peeler/pole or saw log regime. Additionally top logs from larger trees might be suitable, but this would depend on form and branch size. While larger trees would allow the production of more small posts, a lot of wood would be unutilised and returns should greatly improve cutting larger posts or poles. Therefore 2 log supply scenarios focusing on smaller trees are considered for the following calculations:

- Short rotation post regime
  600 stems per hectare grown to 20 or 30 cm DBH (10 or 15 years on good sites).
- Commercial thinnings
  Commercial thinning of peeler/sawlog regime at DBH 20 cm (10 years on good sites) from 600 to 200 stems per hectare.

5.2. Small scale

A mobile post peeler can produce 60-225 posts per hour of 2.4 m length and 40 – 250 (average 100) mm diameter (see 10.3 Table 4). These posts are not cylindrical and the productions rate decreases with the amount of sapwood that needs to be removed. In an 8 hour day at a rate 120 posts per hour 960 posts could be produced. This amounts to 240,000 posts per year, assuming 250 work days. However, the need and time to remove sapwood needs to be verified and would reduce capacity accordingly. Experience from Super Forest Plantations (Australia) (see 10.6, Lausberg (2019)) using a spindle-less debarking lathe is 250 posts per day from already debarked logs, reducing capacity to a quarter (62,500 posts per year).

Table 1 shows the plantation area needed to sustainably supply a small post production mill for different plantation regimes. The total plantation area would need to increase with a reduced (heartwood) growth rate, as trees would need to be grown for longer to reach the target DBH. The annual (and consequently total) plantation area would need to increase for rejected logs (e.g. unsuitable form). While the posts would be the only main product from the post regime management strategies, the peeler/saw log regime should generate the main value from the remaining crop, with the commercial thinnings almost conceivable as a valuable by-product. A clearfell pole operation in blackbutt by Forests NSW was reported to fetch up to $AU 300 per m^3 on wharf without further processing (see 10.2 Figure 7). Commercial thinnings might require a flat site, increasing land costs.

Table 1: Forest area needed to sustainably supply a small post production business, which produces 62.500 2.4 m long; 80 mm diameter heartwood posts per year from improved E. bosistoana on a good site.

Log supply	Available trees / ha	Number of trees / year	Annual planting area (ha / year)	Sustainable plantation area (ha) – good site
Post regime – clear-fell at 20 cm DBH	600	24,500	40.8	408
Post regime – clear-fell at 30 cm DBH	600	9,500	15.8	237
Peeler/saw log regime - commercial thinning (20 cm DBH)	400	24,500	61.3	613

5.3. Large scale

While a large scale post producing sawmill reported to produce 22,000 posts per day amounting to several million posts per year (see 10.7 Figure 17), rounding machine producers state at least 2,000 posts of 2.4 m length per 8 hours shift (see 10.5). The yearly capacity would be 500,000 2.4 m long posts in a 1 shift and 1 million 2.4 m long posts in a 2 shift operation, assuming 250 work days per year. Such posts would be cylindrical and the sapwood easily removed.

Like for the small scale scenario, Table 2 shows the plantation area needed to sustainably supply a large post production mill. The same restriction apply.

Table 2: Forest area needed to sustainably supply a large post production business, which produces 500,000 2.4 m long; 80 mm diameter heartwood posts per year from improved E. bosistoana on a good site.

Log supply	Available trees / ha	Number of trees / year	Annual planting area (ha / year)	Sustainable plantation area (ha) – good site
Post regime – clear-fell at 20 cm DBH	600	195,000	325	3,250
Post regime – clear-fell at 30 cm DBH	600	75,000	125	1,875
Peeler/saw log regime - commercial thinning at 20 cm DBH	400	195,000	488	4,875

6. Economy of post-production

The value of 2.4 m long 80 mm diameter heartwood posts from a single improved naturally durable *E. bosistoana* tree depending on its diameter can be approximated from the stem length having more than 80 mm heartwood (Figure 1) and the post prices (see 3.1). The value of such posts, which can be recovered from a single improved *E. bosistoana* tree, is $NZ 42 and $NZ 105 at a DBH of 20 cm and 30 cm, respectively.

The value of the recoverable products per tree will increase, in particular for the larger trees, if more, i.e. larger, post diameters would be considered (Tian 2019).

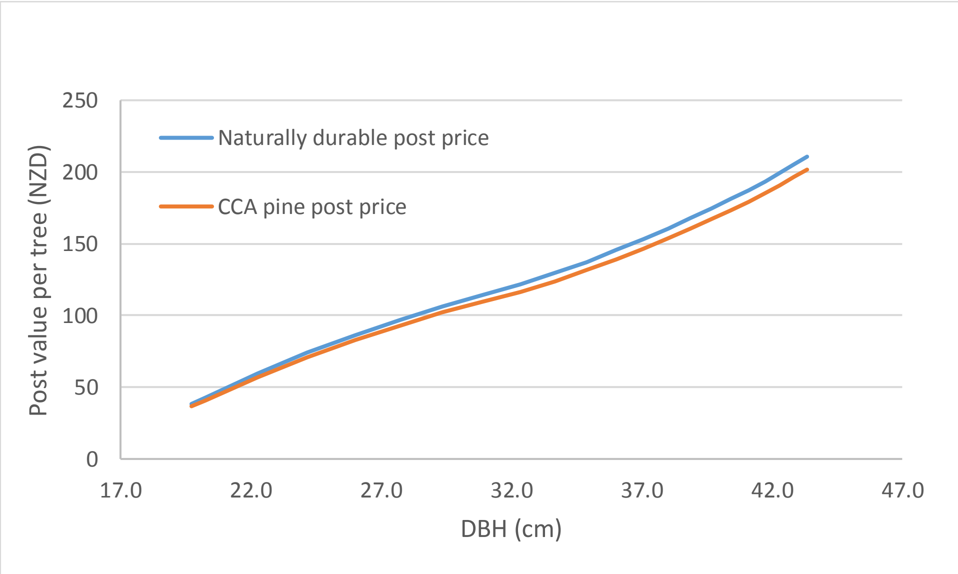

Figure 2: Value of 80 mm diameter posts in an improved E. bosistoana tree depending on its diameter.

Stumpage prices including an 8% internal rate of return (IRR) for the grower have been estimated for *E. bosistoana* (Millen, Altaner et al. 2019). These range from $NZ 12 to $NZ 81 per m^3 for a 15 to 20 year rotation peeler pole regime depending on growth rate and government subsidies (1BT grant). With a tree volume of 0.68 m^3 at 30 cm DBH, stumpage costs per tree would range from $NZ 21 to $NZ 56 to provide growers with an 8% internal rate of return. Coppice or post regimes as well as commercial thinning of sawlog plantations, have not been modelled.

The available estimate of the raw material costs for a post producer of $NZ 21 to $NZ 56 compared favourably to the estimated post product value of $NZ 105 for 30 cm DBH *E. bosistoana* trees. The difference between the prices will need to cover harvesting, transport, post-production and manufacturer profit.

It should be noted that the estimated post product value would increase if larger diameter posts are considered and a premium for class 1 durable posts compared to class 2 or preservative treated posts can be achieved. Utilisation of by-products (e.g. firewood) will also contribute to the profitability.

A $NZ 1 million or $NZ 8.4 million export volume could be achieved with the small and large scale post operations outlined above, respectively.

7. Knowledge gap

From the NZDFI perspective the following points need further information

- Debarking
  Some eucalypts, in particular the stringybark *E. globoidea*, can have thick stringy bark, which might interfere with processing equipment. If bark is not removed during harvest, post processing equipment needs to be tested, if it is able to cope with the bark of the NZDFI eucalypts.
- Sapwood
  Does all sapwood need to be removed, i.e. is there a need for pure heartwood posts? There is a market for debarked chestnut and robinia posts, which have narrow bands of sapwood. Untreated, non-durable posts are also used for fencing in the Alps. Durability/post performance tests could be undertaken.
- Heartwood volume
  Little information on the taper and diameter of heartwood in the NZDFI trees is available. Heartwood volume will impact on the post yield / rotation age and consequently the profitability of a post operation. Genetic, site as well as stocking effects might be relevant.
- Natural durability
  Natural durability varies with a species, between trees, between sites and with a tree (with wood close to the pith being less durable (AS5604 2005)). For example juvenile robinia heartwood was found to be class 4 instead of class 1-2 durable (Koch and Dünisch 2007). Genetic and site influences should be understood and exploited to produce a consistent quality product (Li, Apiolaza et al. 2018).
- Post market
  While retail prices for posts are accessible, little information is available on the volume of the post markets in New Zealand and overseas.
- Log resource
  Log specifications, supply volume and prices should be researched in more detail for the existing industry based on radiata and potentially Douglas fir. What is the benefit of pruning?
- Plantation regimes
  Growth and yield functions for heartwood need to be developed for a better understanding of the plantation regimes. Virtually no knowledge on coppice management for those species exists, but this might be a viable option considering chestnut estates in Europe.
- Manufacturing costs
  Harvesting, transport and in post production costs need to be estimated in order to assess the profitability of a manufacturing naturally durable posts from *E. bosistoana* plantations. Production costs will vary between post product, employed technology as well as scale of the operation.
- Economic analysis
  Additional plantation regimes (e.g. commercial thinning or coppice) should be modelled for their growing costs. Rather than whole stems, growth models need to consider heartwood. A sensitivity analysis of numerous factors (regime, stem properties, post properties, production process) can indicated where focus areas for research and development.
- Posts for structural products

While some work on using posts, in particular peeler cores, for structural purposes has been conducted internationally (Wolfe, King et al. 2000) and patents filed (LOGGO 2018), there is scope to revisit this area, in particular in regards of connections and the material properties of durable heartwood.

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10. Appendix

10.1. Post sizes

Table 3: Typical NZ post sizes (Anonymous 2016)

	Cross section	No 1	No 2	No 3	No 4	Length
	SED		(mm)			(m)
Round Posts & Stays	diameter	115-140	90-114	65-89		1.8; 2.1; 2.4; 2.7; 3.0; 3.6
Half Rounds	flat face	160-180	140-159			1.8; 2.1; 2.4; 2.7; 3.0;
Quarter Rounds	flat face	100-130	75-99	65-74		1.8; 2.4; 2.7; 3.0
Strainers	diameter	200-225	175-199	150-174	140-149	1.8; 2.1; 2.4; 2.7; 3.0; 3.6

10.2. Overseas examples

Figure 3: Debarked robina posts showing sapwood band.

Figure 4: Chestnut coppice in Southern Italy and harvest (Photographs Visser 2019)

Figure 5: Chestnut logs for post/fence production. The video shows the whole process of post and fence manufacture at www.audvardfreres.com. Video link https://www.youtube.com/watch?v=cEvXQtfCMv4

Figure 6: Disc debarker/peeler for chestnut production. The video shows the whole process of post and fence manufacture at www.blehen.com.
<https://www.youtube.com/watch?v=vm4uhNkaSYc>

Figure 7: Clearfell blackbutt pole operation on flat land by Forests NSW using two harvesting machines one felling and the other delimbing/debarking and cutting to length (left). Debarked poles reported to fetch up to $AUS 300 per m^3 at wharf (right).

10.3. Post peelers "disc type"

Table 4: Selection of 'disc type' post peeling equipment with some performance information

Manufacturer	Model	Capacity	Diameter range	Link
			Mobile	
Rabaud	Robopel 150		40 – 150 mm	https://www.rabaud.com/en/products/post-peeler/post-peeler-robopel-150.html?filiere=forestiere
Rabaud	Robopel 250	60 – 120 post/h	40 – 250 mm	https://www.rabaud.com/en/products/post-peeler/post-peeler-robopel-250.html?filiere=forestiere
Deinhammer	Entrindungsmaschine S		50 – 250 mm	https://www.entrindungsmaschine.com/en/
Posch	SchälProfi	9 m / min	70 – 240 mm	https://www.posch.com/en/products/debarking/
			Stationary	
Bezner-Oswald	Post Peeler WP 35		40 – 200 mm	https://www.bezner-oswald.com/products/wood-peelers/

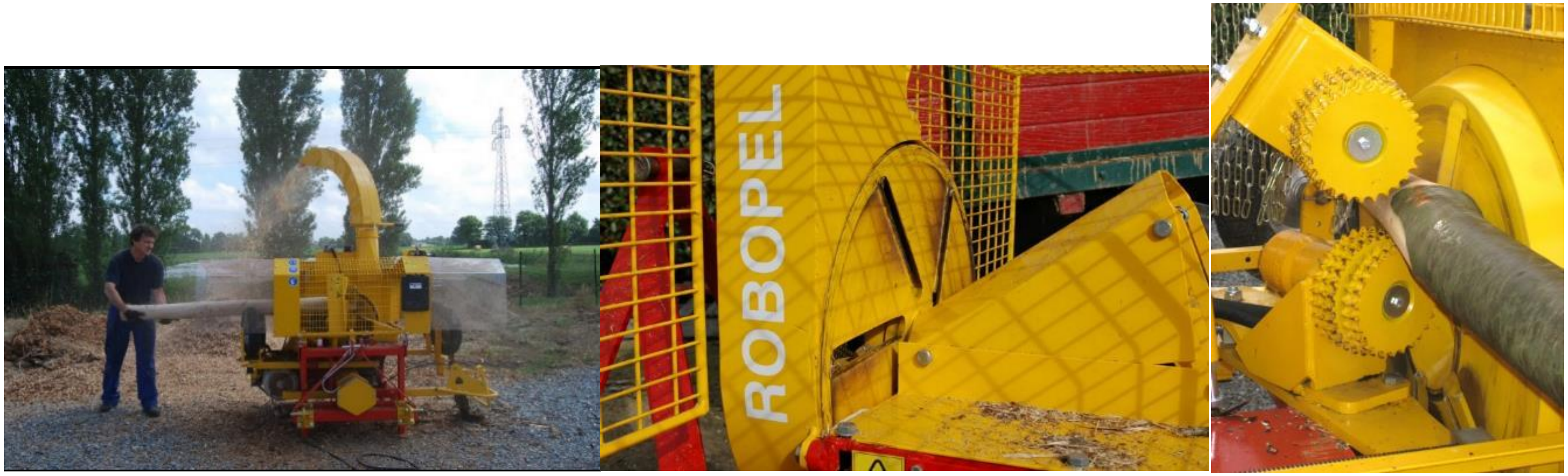

Figure 8: examples of mobile 'disc type' post peelers. Videos of the machines in operation from different manufactures can be seen under the following links: https://youtu.be/boDiJ84aAvc; https://youtu.be/7RxdCpEafug; https://youtu.be/5TnsOViPKP4.

Figure 9: Higher capacity automated stationary 'disc type' post peeler from www.bezner-oswald.com/. A video of the machine in operation can be seen at https://youtu.be/NVIWasF1ayI.

10.4. Pole peelers

Table 5: Selection of pole peeling equipment with some performance information

Manufacturer	Model	Capacity	Post diameter	Post length	Link
			'Rosserhead type'		
Morbark	PSP Pole and Post Peeler	12.2 m/min	78 – 305 mm	1.8 m - 7.6 m	https://www.morbark.com/product/psp-pole-and-post-peeler/
Morbark	PS8	up to 2,000 eight-foot (2.4 m) / 8 h	78 – 305 mm	1.8 m - 3.6 m	https://www.morbark.com/product/ps8-post-peeler/
Bezner-Oswald	Pole Peeler FML		80 – 400 mm	>4 m	https://www.bezner-oswald.com/products/wood-peelers/
			'drawknife'		
Woodlandia	Log Peeler CLP	7 – 15 m/h	180 – 800 mm	2.5 – 13 m	http://www.woodlandia.ca/machines/log-peeler/log-peeler-clp-1

Figure 10: Higher capacity automated stationary 'rosser head type' pole peeler from www.morbark.com. A video of the machine in operation can be seen at https://www.youtube.com/watch?v=t5mVVhd8Vfw.

Figure 11: Higher capacity automated stationary 'rosser head type' pole peeler from www.bezner-oswald.com. A video of the machine in operation can be seen at https://youtu.be/HX_5qIZUtLM?t=37.

Figure 12: 'Draw-knife' post peeler from www.woodlandia.ca . A video of the machine in operation can be seen at http://www.woodlandia.ca/machines/log-peeler/log-peeler-clp-1.

10.5. Rounding / dowel machines

Table 6: Selection of rounding / dowel machines with some performance information

Manufacturer	Model	Capacity	Post diameter	Post length	Link
Bezner-Oswald		35 m/min	30 to 400		https://www.bezner-oswald.com/products/rounding-machine/
Woodlandia	LR 160	3 – 8 m/min	60 – 160 mm	>1.6 m	http://www.woodlandia.ca/machines/machines/log-rounding-machines
Woodlandia	LR 240	2.5 – 8 m/min	85 – 240 mm	>2 m	http://www.woodlandia.ca/machines/machines/log-rounding-machines
Woodlandia	LR 320	1 – 8 m/min	160 – 320 mm	>2 m	http://www.woodlandia.ca/machines/machines/log-rounding-machines
Montana Manufacturing	Dowel Mill	3.2 m / min	51 – 355 mm	2.5 – 13 m	www.montanamfg.com

Figure 13: Rounding / dowel machines from www.montanamfg.com. A video of the machine in operation can be seen at https://www.youtube.com/watch?v=Rkj8CVRj3lk.

Figure 14: Rounding / dowel machines www.bezner-oswald.com. A video of the machine in operation can be seen at https://youtu.be/KJVEsVWf4LY.

10.6. Rotary veneer peeling lathes

The major plywood machinery manufacturers are https://www.raute.com/ and https://www.usnr.com/en/page/home. Raute also offers spindle-less lathes to peel peeler cores from spindled lathes. For a video see https://www.usnr.com/en/page/vidgall-veneer?dt=1.

Numerous spindle-less debarkers/lathes are now available from Chinese manufacturers. The most trusted ones are http://www.rotategold.cn/en/showproduct.asp?id=45 or http://en.baishengyuan.cc/product/57.html.

Figure 15: Spindle less lathe used for eucalypt post manufacturing by www.superforestplantations.com.au/. Log length up to 2.5m; diameter range 80 – 400 mm. Lathe requires debarked logs (220 mm above bark for 100 mm heartwood post from commercial thinning. 250 posts / day. Now tested for durability and strength. $40/post ($14/m for 2.6m posts) (Lausberg, 2019).

Figure 16: Peeling of durable NZDFI eucalypt for veneer 2019 at NPI Ltd for a SWP project (left). Dry veneers and peeler cores (right).

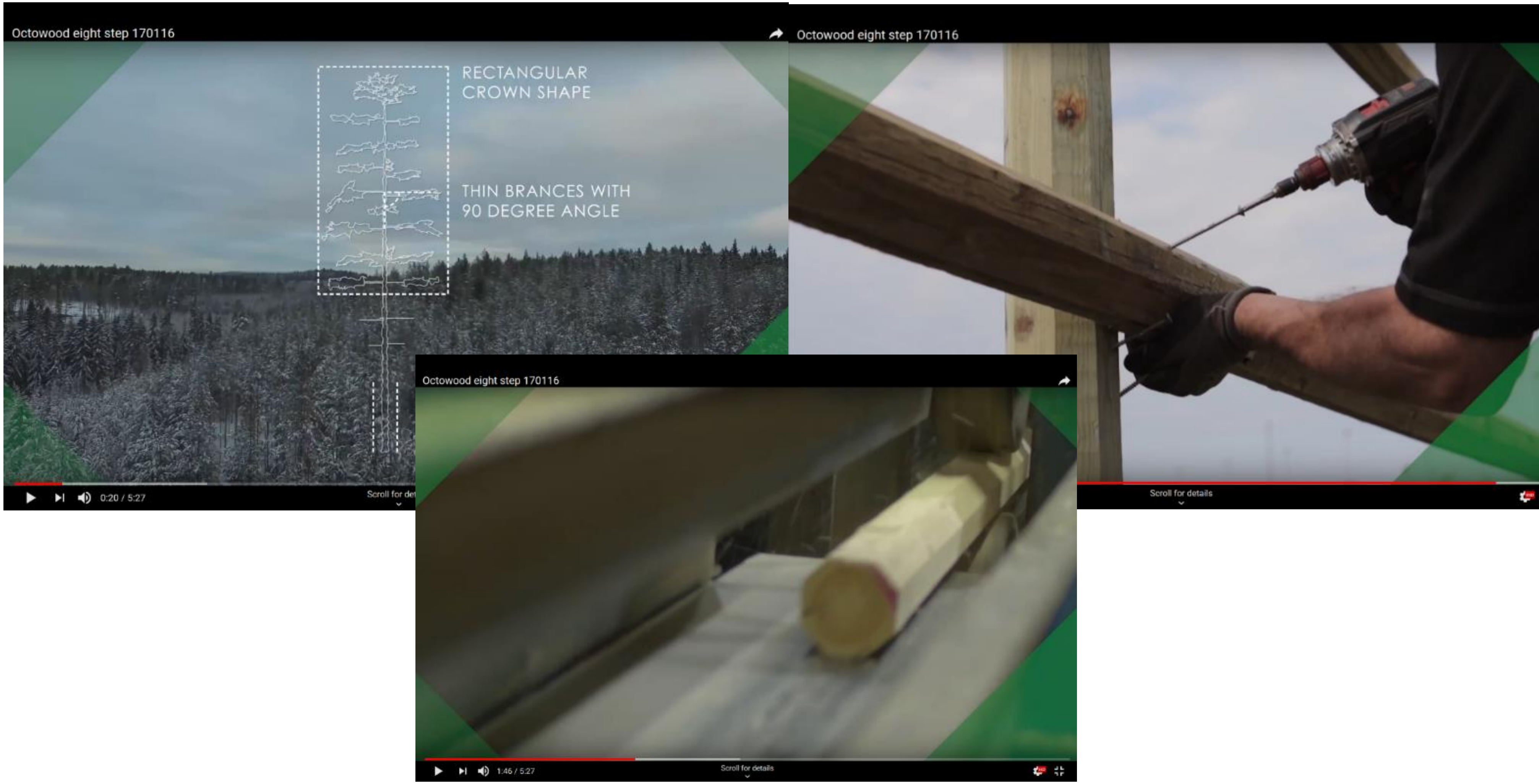

Figure 17: Large scale post production of slow grown 70-80 year old trees pine (Pinus sylvestris) in Northern Sweden at www.octowood.se/en/. 1 post with centred pith is cut in a sawmill form each log with a DBH 180 mm. Sawmill capacity: 22,000 posts pointed and chamfered per day in 2 shifts are dried and impregnated with copper based preservative Tanalith E-7 (NTR class A / SS-EN351-1 NP5). Exported via rail and ship The video shows the whole process https://www.youtube.com/watch?v=hP7OoI11LTI

10.7. Sawing

Figure 18: Sawing 4 square heartwood posts from larger diameter durable eucalypt logs with a mobile horizontal bandaw. Note the distortion during sawing due to growth stresses.

10.8. Pointing and chamfering

Figure 19: Pointing machine using hydraulic driven blades from www.rabaud.com/en/products/forestry-machines. A video of the machine in operation can be seen at https://youtu.be/oganPty8Ems.

https://www.bezner-oswald.com/products/chamfering-pointing-machine/

Figure 20: Pointing and chamfering machine from https://www.bezner-oswald.com/products/chamfering-pointing-machine/ (left) and http://www.brodbaek.dk/Files//Billeder/Brodbaek/Datablade_PDF/Engelsk/64.002%20Post%20Pointing%20160215.pdf.

Figure 21: Fence post pointer and domer from Montana manufacturing https://www.youtube.com/channel/UCZnet2biWB3UlF0nXOxFvvA. A video of the machine in operation can be seen at https://www.youtube.com/watch?v=8Vr2dJ0qaB8.

10.9. Post prices

Table 7: Selection of 2019 retail prices of CCA treated round pine posts

Retailer	Product	Piece price NZD	Length (m)	Diameter (mm)	Retail price NZD per lineal m	Volume (m^3)	Retail price NZD per m^3
Thomsons ITM	Round 1.8m H4 No.2	$ 15.00	1.8	90	$ 8.33	0.011451	$ 1,309.92
Thomsons ITM	Round 2.4m H4 No.2	$ 20.55	2.4	90	$ 8.56	0.015268	$ 1,345.94
Thomsons ITM	Round 2.7m h4 No.2	$ 23.41	2.7	90	$ 8.67	0.017177	$ 1,362.90
NZ Timber		$ 12.50	1.8	90	$ 6.94	0.011451	$ 1,091.60
Canterbury timber	1.8 x 100	$ 13.08	1.8	100	$ 7.27	0.014137	$ 925.22
Canterbury timber	2.7 x 100	$ 31.22	2.7	100	$ 11.56	0.021206	$ 1,472.24
Canterbury timber	2.4 x 100	$ 25.70	2.4	100	$ 10.71	0.01885	$ 1,363.43
Canterbury timber	1.8 x 110-130	$ 17.72	1.8	110	$ 9.84	0.017106	$ 1,035.90
Thomsons ITM	Round 1.8m H4 No.1	$ 18.52	1.8	115	$ 10.29	0.018696	$ 990.56
NZ Timber		$ 18.90	1.8	115	$ 10.50	0.018696	$ 1,010.89
Rangitikei Timber		$ 17.33	1.8	115	$ 9.63	0.018696	$ 926.92
Canterbury timber	1.8 x 125	$ 19.75	1.8	125	$ 10.97	0.022089	$ 894.10
Canterbury timber	2.7 x 125	$ 30.40	2.7	125	$ 11.26	0.033134	$ 917.49
Canterbury timber	2.7 x 125	$ 28.95	2.7	125	$ 10.72	0.033134	$ 873.73
Canterbury timber	2.4 x 125	$ 25.69	2.4	125	$ 10.70	0.029452	$ 872.25
Canterbury timber	1.8 x 130-160	$ 21.41	1.8	130	$ 11.89	0.023892	$ 896.12
Canterbury timber	2.7 x 130-160	$ 35.41	2.7	130	$ 13.11	0.035838	$ 988.07
Canterbury timber	1.8 x 140	$ 20.70	1.8	140	$ 11.50	0.027709	$ 747.05
Canterbury timber	1.8 x 140	$ 14.20	1.8	140	$ 7.89	0.027709	$ 512.47
Canterbury timber	1.8 x 150	$ 21.69	1.8	150	$ 12.05	0.031809	$ 681.89
Canterbury timber	2.4 x 150	$ 28.93	2.4	150	$ 12.05	0.042412	$ 682.13
Canterbury timber	2.7 x 150	$ 37.83	2.7	150	$ 14.01	0.047713	$ 792.87
Canterbury timber	2.1 x 150	$ 32.62	2.1	150	$ 15.53	0.03711	$ 879.01
Canterbury timber	2.4 x 150	$ 37.66	2.4	150	$ 15.69	0.042412	$ 887.97
Canterbury timber	2.7 x 150	$ 42.43	2.7	150	$ 15.71	0.047713	$ 889.28
Canterbury timber	3.0 x 150	$ 48.90	3	150	$ 16.30	0.053014	$ 922.39
Thomsons ITM	Strainer 2.4m H4 No.3	$ 31.83	2.4	150	$ 13.26	0.042412	$ 750.50
Thomsons ITM	Strainer 2.1m H4 No.3	$ 27.99	2.1	150	$ 13.33	0.03711	$ 754.24
Thomsons ITM	Strainer 3.0m H4 No.3	$ 47.28	3	150	$ 15.76	0.053014	$ 891.83
NZ Timber		$ 30.26	2.4	150	$ 12.61	0.042412	$ 713.49
Kiwi Timber supplies	Strainer 3.6m H5 No.3	$ 75.90	3.6	150	$ 21.08	0.063617	$ 1,193.07
Canterbury timber	1.8 x 155	$ 22.85	1.8	155	$ 12.69	0.033965	$ 672.76
Canterbury timber	2.1 x 160-180	$ 38.40	2.1	160	$ 18.29	0.042223	$ 909.46
Canterbury timber	2.4 x 160-180	$ 42.75	2.4	160	$ 17.81	0.048255	$ 885.92
Canterbury timber	2.1 x 175	$ 37.82	2.1	175	$ 18.01	0.050511	$ 748.75
Canterbury timber	2.4 x 175	$ 40.96	2.4	175	$ 17.07	0.057727	$ 709.55

Canterbury timber	2.7 x 175	$ 47.82	2.7	175	$ 17.71	0.064943	$ 736.34
Canterbury timber	3.0 x 175	$ 62.77	3	175	$ 20.92	0.072158	$ 869.89
Thomsons ITM	Strainer 2.1m H4 No.2	$ 37.42	2.1	175	$ 17.82	0.050511	$ 740.83
Thomsons ITM	Strainer 3.0m H4 No.2	$ 60.31	3	175	$ 20.10	0.072158	$ 835.80
Thomsons ITM	Strainer 2.4m H4 No.2	$ 45.26	2.4	175	$ 18.86	0.057727	$ 784.04
Thomsons ITM	Strainer 2.7m H4 No.2	$ 48.44	2.7	175	$ 17.94	0.064943	$ 745.89
NZ Timber		$ 49.95	3	175	$ 16.65	0.072158	$ 692.23
NZ Timber		$ 39.95	2.1	175	$ 19.02	0.050511	$ 790.92
Kiwi Timber supplies	Strainer 2.4m H4 No.2	$ 42.53	2.4	175	$ 17.72	0.057727	$ 736.75
Rangitikei Timber		$ 41.05	2.4	175	$ 17.10	0.057727	$ 711.11
Canterbury timber	2.4 x 180	$ 40.45	2.4	180	$ 16.85	0.061073	$ 662.33
Canterbury timber	2.7 x 180	$ 44.48	2.7	180	$ 16.47	0.068707	$ 647.39
Canterbury timber	3.0 x 180	$ 62.45	3	180	$ 20.82	0.076341	$ 818.04
Thomsons ITM	Strainer 3.0m H4 No.1	$ 65.16	3	200	$ 21.72	0.094248	$ 691.37
Thomsons ITM	Strainer 2.7m H4 No.1	$ 65.16	2.7	200	$ 24.13	0.084823	$ 768.19
Thomsons ITM	Strainer 2.4m H4 No.1	$ 53.79	2.4	200	$ 22.41	0.075398	$ 713.41
Thomsons ITM	Strainer 2.1m H4 No.1	$ 49.55	2.1	200	$ 23.60	0.065973	$ 751.06
Kiwi Timber supplies	Strainer 4.8m H5 No.1	$ 159.85	4.8	200	$ 33.30	0.150796	$ 1,060.04
Kiwi Timber supplies	Strainer 6.0m H5 No.1	$ 209.30	6	200	$ 34.88	0.188496	$ 1,110.37
Canterbury timber	2.1 x 180	$ 37.57	2.1	280	$ 17.89	0.129308	$ 290.55
Average					**$ 15.49**		**$ 868.90**

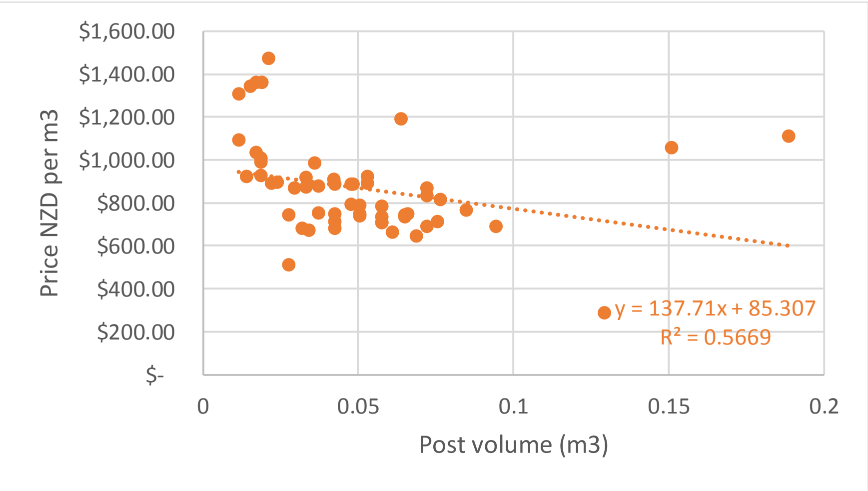

Figure 22: Relationship of post volume to retail price per volume for CCA treated radiata pine

Table 8: Selection of 2019 retail prices of naturally durable round posts

Retailer	Length (m)	Diameter (mm)	Currency	Price	Currency conversion factor	Piece price $NZ	Volume (m^3)	Price $NZ per lineal m	Price $NZ per m^3
					Chestnut (*C. sativa*)				
blehen.com	1.6	80	Euro	3.09	1.69	5.22	0.008042	3.26	649.31
blehen.com	2	80	Euro	4.24	1.69	7.17	0.010053	3.58	712.78
blehen.com	2.5	80	Euro	5.96	1.69	10.07	0.012566	4.03	801.54
Average retailer								*3.63*	*721.21*
naturzaun.com	2	40	Euro	5.1	1.69	8.62	0.002513	4.31	3429.39
naturzaun.com	2.5	40	Euro	5.9	1.69	9.97	0.003142	3.99	3173.87
naturzaun.com	1.25	80	Euro	4.9	1.69	8.28	0.006283	6.62	1317.96
naturzaun.com	1.5	80	Euro	5.9	1.69	9.97	0.00754	6.65	1322.44
naturzaun.com	1.75	80	Euro	6.9	1.69	11.66	0.008796	6.66	1325.65
naturzaun.com	2	80	Euro	7.9	1.69	13.35	0.010053	6.68	1328.05
naturzaun.com	2.5	40	Euro	6.1	1.69	10.31	0.003142	4.12	3281.46
naturzaun.com	3	40	Euro	7.9	1.69	13.35	0.00377	4.45	3541.46
naturzaun.com	2.5	60	Euro	8.4	1.69	14.20	0.007069	5.68	2008.32
naturzaun.com	3	60	Euro	9.8	1.69	16.56	0.008482	5.52	1952.54
naturzaun.com	3	80	Euro	11.9	1.69	20.11	0.01508	6.70	1333.65
naturzaun.com	4	80	Euro	22.9	1.69	38.70	0.020106	9.68	1924.83
Average retailer								*5.92*	*2161.64*
Average chestnut								**4.77**	**1441.42**
					Durable eucalypt				
Super Forest Plantations	1	120	AUD	16	1.04	16.64	0.01131	16.64	1471.30
Super Forest Plantations	2.2	300	AUD	33	1.04	34.32	0.155509	15.60	220.69
Super Forest Plantations	2.2	150	AUD	16.5	1.04	17.16	0.038877	7.80	441.39
Average durable eucalypt								**13.35**	**711.13**
					Robinia (*Robinia pseudoacacia*)				
blehen.com	1.6	60	Euro	3.13	1.69	5.29	0.004524	3.31	1169.28
blehen.com	2	60	Euro	3.91	1.69	6.61	0.005655	3.30	1168.53
blehen.com	1.8	80	Euro	5.61	1.69	9.48	0.009048	5.27	1047.87
blehen.com	2	80	Euro	6.23	1.69	10.53	0.010053	5.26	1047.31
blehen.com	2.5	80	Euro	8.08	1.69	13.66	0.012566	5.46	1086.65
blehen.com	1.8	100	Euro	8.07	1.69	13.64	0.014137	7.58	964.71
blehen.com	2	100	Euro	8.97	1.69	15.16	0.015708	7.58	965.07
blehen.com	2.5	100	Euro	11.22	1.69	18.96	0.019635	7.58	965.72
Average retailer								*5.67*	*1051.89*

naturzaun.com	3	100	Euro	37.9	1.69	64.05	0.023562	21.35	2718.41
naturzaun.com	4	100	Euro	54.5	1.69	92.11	0.031416	23.03	2931.79
naturzaun.com	5	100	Euro	96.5	1.69	163.09	0.03927	32.62	4152.93
naturzaun.com	3	140	Euro	66.5	1.69	112.39	0.046181	37.46	2433.55
naturzaun.com	4	140	Euro	95.9	1.69	162.07	0.061575	40.52	2632.08
naturzaun.com	5	140	Euro	159.9	1.69	270.23	0.076969	54.05	3510.91
naturzaun.com	4	180	Euro	146	1.69	246.74	0.101788	61.69	2424.07
naturzaun.com	5	180	Euro	240	1.69	405.60	0.127235	81.12	3187.81
naturzaun.com	1.25	60	Euro	3.75	1.69	6.34	0.003534	5.07	1793.15
naturzaun.com	1.6	60	Euro	4.6	1.69	7.77	0.004524	4.86	1718.43
naturzaun.com	1.8	60	Euro	5.2	1.69	8.79	0.005089	4.88	1726.73
naturzaun.com	2	60	Euro	5.9	1.69	9.97	0.005655	4.99	1763.26
naturzaun.com	2.5	60	Euro	7.4	1.69	12.51	0.007069	5.00	1769.24
naturzaun.com	1.6	80	Euro	6.5	1.69	10.99	0.008042	6.87	1365.87
naturzaun.com	1.8	80	Euro	7.8	1.69	13.18	0.009048	7.32	1456.93
naturzaun.com	2	80	Euro	8.9	1.69	15.04	0.010053	7.52	1496.16
naturzaun.com	2.5	80	Euro	12.8	1.69	21.63	0.012566	8.65	1721.42
naturzaun.com	1.6	100	Euro	10.5	1.69	17.75	0.012566	11.09	1412.10
naturzaun.com	1.8	100	Euro	11.8	1.69	19.94	0.014137	11.08	1410.61
naturzaun.com	2	100	Euro	12.5	1.69	21.13	0.015708	10.56	1344.86
naturzaun.com	2.25	100	Euro	15.8	1.69	26.70	0.017671	11.87	1511.02
naturzaun.com	2.5	100	Euro	17.5	1.69	29.58	0.019635	11.83	1506.24
naturzaun.com	3	100	Euro	21.9	1.69	37.01	0.023562	12.34	1570.80
naturzaun.com	2.5	140	Euro	31.5	1.69	53.24	0.038485	21.29	1383.28
naturzaun.com	3	140	Euro	39.8	1.69	67.26	0.046181	22.42	1456.47
Average retailer								*20.78*	*2015.93*
Average Europe								***13.22***	***1533.91***
robidecking.com	0.305	127	USD	15	1.52	5.29	0.003864	74.75	5901.16
robidecking.com	0.305	178	USD	30	1.52	6.61	0.00759	149.51	6008.07
robidecking.com	0.305	229	USD	55	1.52	9.48	0.012562	274.10	6654.96
Average retailer								***166.12***	***6188.07***
mtnworks.org	2.13	102	USD	9	1.52	10.53	0.017405	6.42	785.99
mtnworks.org	2.44	152	USD	24	1.52	13.66	0.044276	14.95	823.93
mtnworks.org	6.4	152	USD	65	1.52	13.64	0.116133	15.44	850.75
Average retailer								*12.27*	*820.22*
Average US								***89.20***	***3504.14***
Average robinia								**51.21**	**2519.03**

10.10. Value added products

Figure 23: Fences products made from chestnut (C. sativa). Left www.blehen.com; right http://www.audvardfreres.com/clotures_decoratives_chataignier.html.

Figure 24: Production of posts and fences from chestnut at https://jehomewood.co.uk/ (left) and www.audvardfreres.com (right). Videos showing the production process can be found at https://www.youtube.com/watch?v=bPe-qDedIi8 and https://www.youtube.com/watch?v=cEvXQtfCMv4.

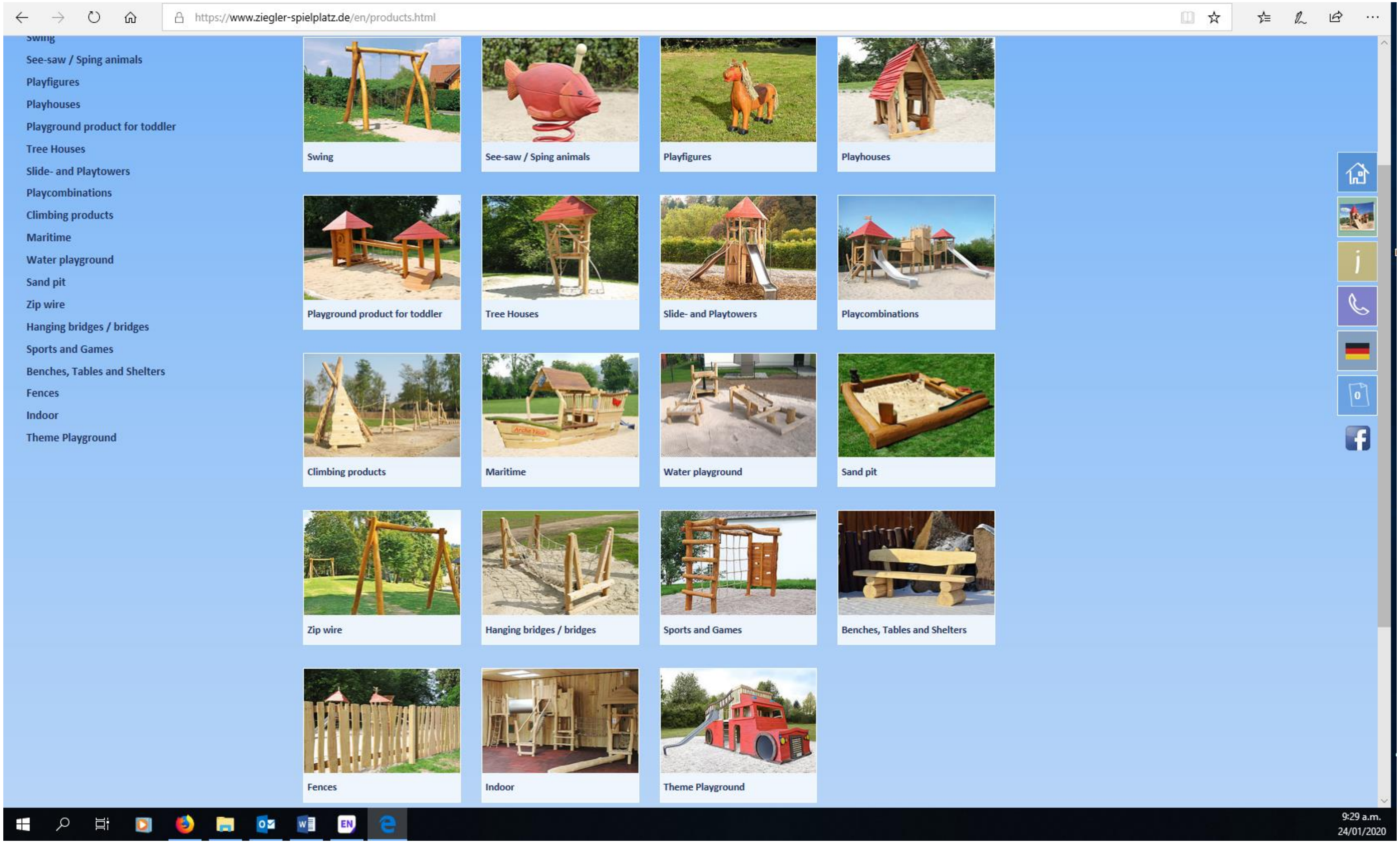

Figure 25: Playground equipment made from robinia by www.ziegler-spielplatz.de/.

Figure 26: Patented composite beam made from peeler cores by www.loggo.com.au. A video of the LOGGO system can be found at https://vimeo.com/54001004.