Plantation-grown whitewood timber in Vanuatu: challenges and opportunities for export and domestic use

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SUMMARY

Whitewood (*Endospermum medullosum)* is a useful timber species, previously sourced from native forests and now available from plantations in Vanuatu. However, plantation-grown whitewood will have about 30% more knotty wood than previously experienced in logs from native forest. This will impact on the economics of growing and processing whitewood, and on potential uses of the timber. Opportunities to add value to knotty wood are to produce large section structural lumber, to recover short lengths of clear wood for furniture, and to treat heartwood with preservative chemicals to enable structural use in exposed and in-ground applications.

Keywords: *Endospermum medullosum*, value-adding, plantations, Vanuatu

Bois de coupe de bois blanc de plantations à Vanuatu: défis et opportunités pour l'exportation et l'usage domestique

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Le bois blanc (*Endospermum medullosum*) est une essence utile, qui provenait auparavant de forêts natives et qui est maintenant disponible en plantation à Vanuatu. Cependant, le bois blanc cultivé en plantation aura un bois 30% plus noueux que le bois obtenu auparavant en provenance des forêts natives. Cela va impacter l'économie de la croissance et de la préparation du bois blanc, ainsi que ses utilisations potentielles. Des opportunités pour ajouter de la valeur aux bois noueux consistent à produire de coupes structurelles à section large, pour récupérer des petites longueurs de bois clair pour le mobilier, et à traiter le coeur du bois avec des produits préservatifs, pour permettre une utilisation structurale dans des applications exposées et dans la terre.

La madera de *Endospermum medullosum* de plantaciones en Vanuatu: retos y oportunidades para la exportación y su uso doméstico

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La madera blanca (*Endospermum medullosum*) es una especie maderable de considerable utilidad, que previamente se aprovechaba del bosque natural y ahora se encuentra disponible procedente de plantaciones en Vanuatu. Sin embargo, la madera de *E. medullosum* de plantaciones contiene cerca de un 30% más de nudos que la de trozas procedentes de bosque natural. Esto tendrá un impacto económico en las operaciones silvícolas y de procesamiento de *E. medullosum*, y en los usos potenciales que se le pueden dar a esta madera. Las opciones para agregar valor a la madera con nudos son el producir madera para la construcción de grandes secciones, el despiezar en pequeñas longitudes de madera libre de nudos para ebanistería, y el tratar el duramen con conservantes químicos que permitan su uso estructural al aire libre y bajo el suelo.

INTRODUCTION

Sustained production of wood products can provide cash for goods and services not available from subsistence agriculture, and thus help rural poor people to overcome poverty and satisfy aspirations (Scherr *et al.* 2003). In addition, domestic wood production and processing may strengthen the balance of trade through export earnings and reduced timber imports. The viability of a timber industry depends on wood properties, the resource available, processing opportunities and market potential. Here we draw on published literature, interviews with industry stakeholders, and a sawing study to examine product development opportunities for plantation grown *Endospermum medullosum* (whitewood) in Vanuatu.

REVIEW

Whitewood is one of the tallest tree species in Vanuatu's forests, and remains one of Vanuatu's premium native timber species. While it typically grows to a height of 40 m, individual trees can attain 60 m in height with a clear bole of 15–30 m and a diameter (above buttress) of 60–100 cm (Thomson 2006). It supplied over half the country's annual log production (Vutilolo *et al.* 2005) until the natural forest was almost exhausted in the early 1990s (McGregor and McGregor 2010).

Whitewood is a light hardwood with a density of 400–450 kg/m^3 and may have conspicuous growth rings (Groves and Wood 1998). It is readily accepted by wood manufacturing industries in both domestic and export markets, and is used locally as a structural timber, in furniture and cabinet making, as veneer and plywood, and for carving. It is susceptible to blue-stain fungi, pinhole borers, marine borers and termites. Logs should be sawn within two days of felling and sawn wood should be air dried to avoid blue-stain. Alternatively, whitewood can be vacuum/pressure treated with copper chrome arsenate (CCA) or copper azole (e.g., Tanalith).

Whitewood is currently sourced from plantations and native forest on Espiritu Santo in the north of Vanuatu, and in smaller quantities from native forests on Efate Island, where the capital Port Vila is located (Figure 1). Most processing of whitewood is by portable sawmill with just one stationary sawmill on Santo (Melcoffee Sawmill Company). First grade green whitewood timbers are sold to timber yards, value-adding processors and to consumers at the prices indicated in Table 1. One pressure treatment plant on Efate operates sporadically, once or twice a month due to limited supply of whitewood timber. Three pressure treatment plants on Santo are fully operational and exert some price control in domestic markets because of whitewood's susceptibility to degrade.

Whitewood secured a niche market for mouldings in Japan during the 1990s, because of its weight, appearance and workability (Thomson 2006), but these exports ceased in 2008 (McGregor and McGregor 2010). The majority of whitewood harvested in the 1990s was exported to Japan by Melcoffee Sawmill Company as kiln dried material at a free on board (FOB) price of \$766–1094 /m^3 for clear boards, \$656 /m^3 for finger-jointed laminated boards and up to \$1,116 /m^3 for laminated board. Currently domestic markets exist for defect-free (clear) wood, and demand exceeds supply.

In Vanuatu, imported softwood is sold at an average price of \$740/m^3 retail, and softwood imports amounted to \$2.1 million in 2011 (Vanuatu National Statistics Office 2012). This represents approximately 5,000 m^3 domestic consumption, mainly in the centres of Port Vila and Luganville. An informal survey of sawn softwood products on sale in Luganville indicated that imported softwood from New Zealand was generally non-structural grades, and highlights a need to educate consumers about timber grades, particularly given the cyclonic conditions that regularly occur in Vanuatu.

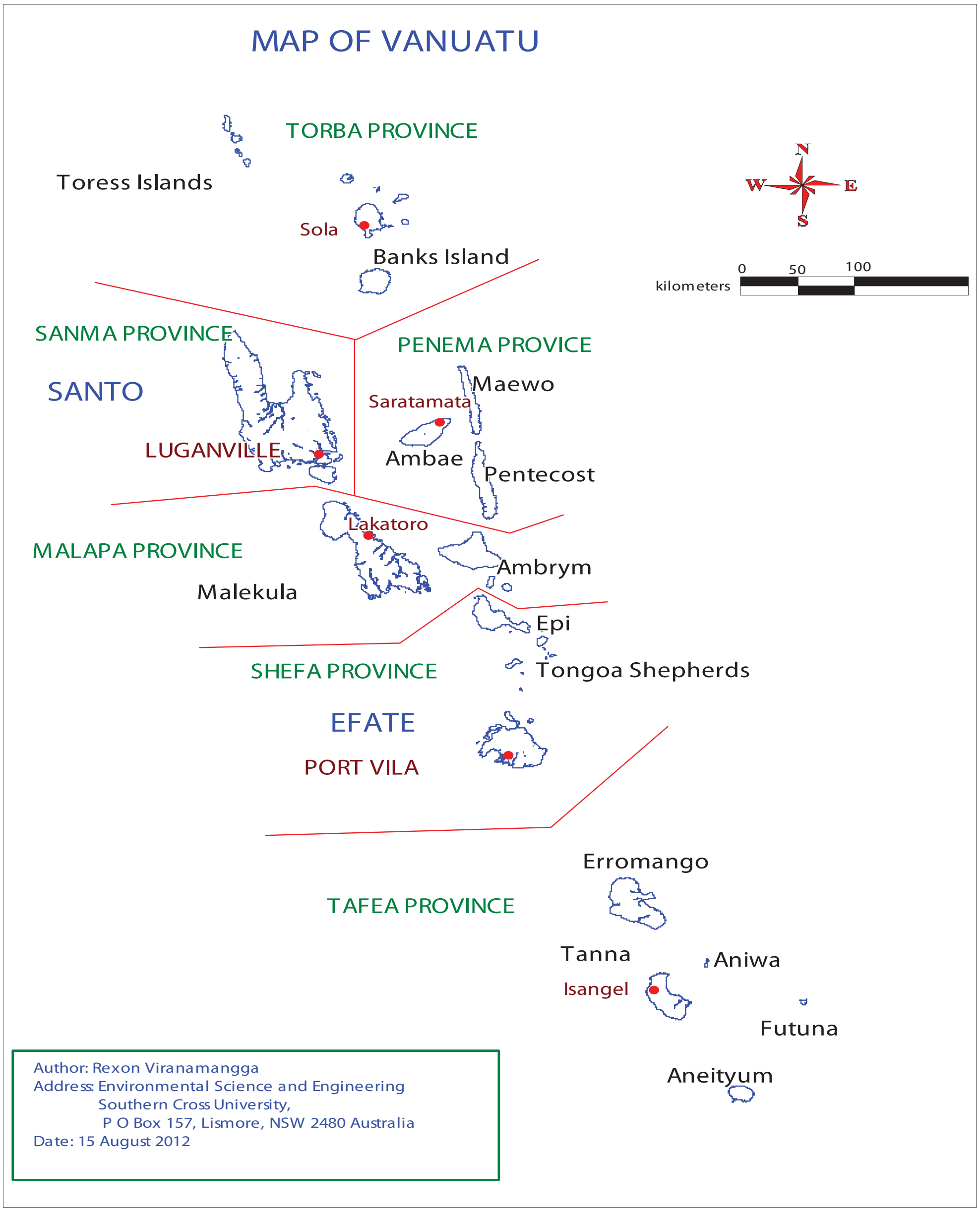
Several issues appear to contribute to the demand for softwood, despite its poor strength. Imported softwood is supplied dry, dressed and in standard 6 m lengths, providing a stable and easily handled product. It is readily available, and commonly delivered to site by hardware stores. Most builders lack sufficient knowledge of timber grading and durability and choose softwood for its convenience rather than strength. Consumers complain that treated whitewood is less durable than imported softwood, a consequence of whitewood treatment aimed at preventing degrade during trade, rather than during service.

In addition, domestic timber demand is greatest in the capital Port Vila, where imports are common and domestic supply is limited, whilst most of the whitewood supply is from Santo 200 kms away by sea. Demand for whitewood on Santo is comparatively small, and unable to support local value-adding because throughput is insufficient to recover capital costs. However, local demand for whitewood is sufficiently strong that it sells at a premium, with the Melanesian Commerce and Industries selling treated whitewood timber at prices higher higher than the average price of NZ pine.

The formerly abundant native forest timber contributed to wasteful practices of selling only the clear boards and discarding lower grade timber. This was possible, because recovery of clear boards from native forest logs was about 50% (personal communication, Neil Croucher, Melcoffee Sawmill Company). Despite the current restricted supply, these wasteful practices have continued, with timber yards purchasing primarily clear grade and rarely second grade timbers. Lower grade timbers are either left at the processing site or scavenged by local people for firewood and temporary structures. This is inefficient, both in terms of utilsation and economics, and it is critical to change these customs to gain resource and economic efficiencies. The sawmill study reported here establishes recovery by grade from plantation material.

A future whitewood industry in Vanuatu will depend on plantation production. Growth rates of about 20 m^3/hectare/year make whitewood plantations a viable proposition (Grant *et al.* 2012). Domestic demand of 5,000 m^3 is currently supplied by imported softwood, and could be displaced by plantation grown whitewood. Annual production of whitewood sawlogs could reach 14,000 m^3/year within 10 years, sufficient to support a viable wood industry if this wood is of sufficient quality. However, plantation growth conditions and harvest age mean this new resource will differ in dimensions and character from the previous native forest resource,

FIGURE 1 *Map of Vanuatu showing the islands of Espirtu Santa and Efate*



and create significant challenges in processing and product development (Nichols and Vanclay 2012).

At current pricing, whitewood is competitive with imported softwood, and security of supply appears to be the main market driver. Existing whitewood plantations in Vanuatu are scattered and will hamper efficient and consistent supply of logs to processors. Most of the current plantation area of 730 hectares is located on the east coast of Santo Island (470 ha), with the remainder of the resource fragmented among 270 sites on 12 islands. Future plantation establishment should expand the estate near processors, and any new developments should be informed by the plantation resource. Efficiencies may be gained by devising preliminary processing in the forest with finishing at a centralised plant. In addition, low cost methods to protect sawnwood from blue staining are needed to encourage improved utilisation of this resource.

TABLE 1 *Lumber prices in Vanuatu*

Stage of processing	**Port Vila (capital city) ($/m^3)**	**Espiritu Santo ($/m^3)**
1st grade, green off saw	$380–$490	$425–$493
1st grade air dried,	$658–$767	$822
1st grade pressure treated	$930	$531

SAWMILL STUDY

Methods

The viability of the plantation industry depends in part on the ability of sawmillers to secure adequate recovery from smaller plantation material, so a sawmill study was conducted to examine sawn wood recovery by grade classes, to investigate mechanical properties of plantation material, and to test the penetration of preservative into whitewood heartwood.

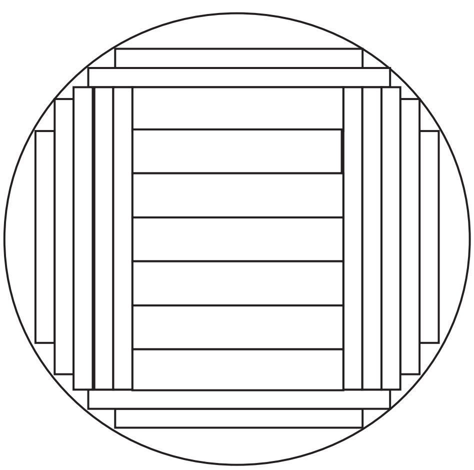
Six whitewood trees were selected in a 16-year-old plantation established by the Melcoffee Sawmill Company at Lorum on the south east coast of Santo Island. This plantation had been established at wide spacing (10 m × 4 m) and manually pruned to approximately 6 m. The six trees, chosen to sample the range in diameter at breast height of the stand, were felled and cross cut in the forest to maximize the yield of straight logs and then transported by road to the Melcoffee sawmill. The average small end diameter of logs was 29.0 cm (range19.2–42.8 cm). The logs were sawn to produce 25 mm boards from the outer clear wood sections, and 50 mm thick random width boards from the knotty, pith-included core (Figure 2), using a primary break-down band saw and a secondary circular rip saw.

The resulting sawn wood was strip stacked and air-dried under cover. Following air drying for 8 weeks, all sawn boards were visually graded by students of the Agricultural College at Luganville under supervision of experienced project staff. Whole boards were sorted into one of four appearance grades: (1) clear wood, (2) clear on one face and edges, (3) knotty wood excluding pith, and (4) pith inclusions. The dimensions of each board were measured using a cloth tape (length) and ruler (thickness and width). Each board was then marked to define clear sections in decimetre lengths between defects, simulating cross cutting.

A random sub sample of 30 boards, nominally 100 × 50 mm was selected from the sawn timber and tested for strength and stiffness in bending. Sample selection and tests were conducted according to the specifications in Australian and New Zealand standard AS/NZS 4063:1992 *Timber – Stress-graded – In-grade strength and stiffness evaluation*. The data derived from these tests were used to calculate basic working stress (R_{basic}) and characteristic stiffness (E_k) in bending and compared to current structural grade specifications used in Australia. Structural grade specifications are determined by the weaker timber in any sample to ensure the whole batch meets the minimum requirement. AS/NZS 4063:1992 *Timber – Stress-graded – In-grade strength and stiffness evaluation* uses the 5th percentile ranked value for various mechanical properties of a population, which is further scaled to account for a safety factor. This means that culling the weakest pieces from a batch of wood increases the overall grade, so the trial examined potential for such culling of whitewood sawnwood. Each board was visually sorted into 4 structural grades, defined as (1) clear wood, (2)boards with small knots (<50 mm diameter) only, (3) boards with large knots (>50 mm), and (4) boards with included pith.

Samples of sawn (4 pieces of 100 mm × 100 mm) and round (2 pieces >100 mm diameter) whitewood were selected from different trees and transported to Australia where they were pressure vacuum treated with Koppers Tanalith E in the Southern Cross University research facility (Lloyd *et al*. 2011). The ends of each sample were coated with a sealant prior to treatment. Penetration of preservative was assessed qualitatively on cross cut sections after treatment.

FIGURE 2 *Typical saw pattern recovering 25 mm thick boards free of defect in random widths and 50 mm thick boards where defect is likely*



Study results

A log volume of 6.35 m^3 (green, over bark) was processed to recover 1.91 m^3 of sawnwood (green off saw), a recovery rate of 30% after docking to nominal sale lengths (i.e., multiples of 0.3 m plus 100 mm over cut allowance). Maximum length was 4 m and minimum length was 2.8 m.

Table 2 shows the proportions of sawn volume recovered for each grade defined, and highlights the lower recovery expected from a young plantation resource (35% clear wood recovery compared to 50% from native forest material), despite pruning the plantation trees at a young age.

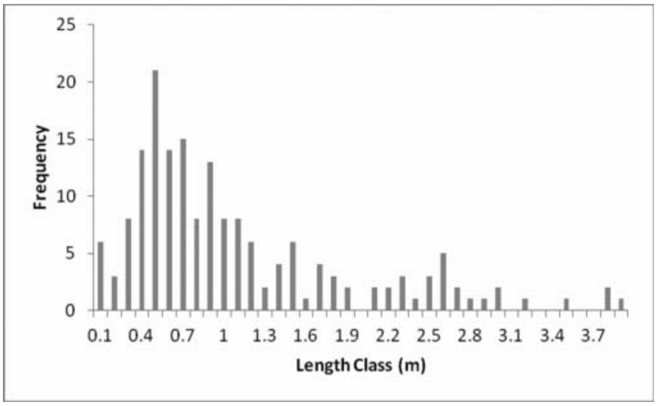
After simulated cross cutting to remove all defects, the recovery of clear wood as a proportion of all sawn timber was determined to be 83%. The distribution of clear wood piece length recovered from simulated cross cutting is shown in Figure 3. The short lengths of clear wood recovered from longer knotty material (Figure 3) reveal the potential to produce clear 'shorts' for furniture joinery.

The basic working stress (R_{basic}) for the sample was 2.3 MPa and characteristic stiffness (E_k) 3812 MPa. The distribution of strength values by visually sorted structural grade is shown in Figure 3. The wide variety in the data indicates

TABLE 2 *Proportion of over bark stem volume recovered in each appearance grade*

Appearance Grade	No of pieces	Proportion of volume (%)
1 = clear faces and edges	25	32%
2 = clear on one face and both edges	2	3%
3 = knotty excluding pith	37	34%
4 = pith included	32	31%
Total	96	100%

FIGURE 3 *Frequency distribution (number of pieces) of clear wood recovered from knotty wood after cross cutting to remove defects*

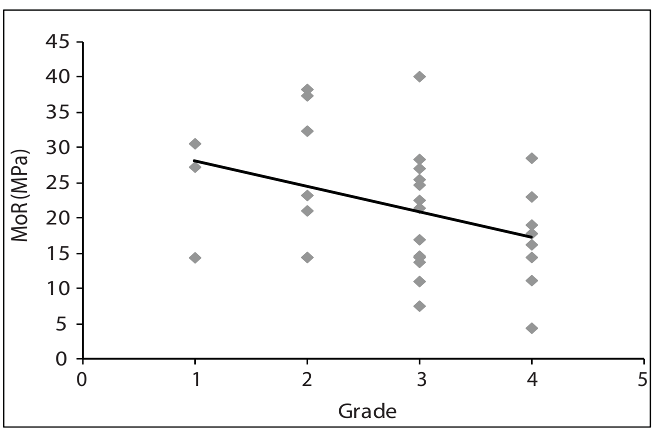


some potential for genetic improvement to achieve higher strength from selected superior trees (Doran *et al.* 2012).

Because of the way that structural grades are determined, culing the weaker pieces from a batch increases the grade of structural outturn. The distribution of strength by grade class shown in Figure 4 indicates that whilst many pieces of whitewood exceed common structural grades used in Australia (AS 1720.1 Timber Structure Part 1 Design Methods), other weaker pieces reduce batch averages. Since all visual grade classes displayed some weaker pieces, it appears that visual grading cannot presently be used to reliably select structural characters. However, structural products may be attainable if a suitable sorting mechanism can be devised. This may be as simple as, for example, measuring wood density if this is the limiting factor.

The stiffness (modulus of elasticity) of whitewood indicates that a sectional dimension of 90 ×45 mm whitewood is approximately equivalent to 70 × 35 mm Australian softwood in a commonly used grade (MGP 10 – Plantation Timber Assoc. Australia, 1996). In respect of strength however, a section of 150 × 60 mm whitewood equates to 70 × 35 mm

FIGURE 4 *Grade versus modulus of rupture for 30 samples of nominally 100 mm × 50 mm whitewood, sorted into grades: 1 = clear wood, 2 = small knots (<50 mm) 3 = some large knots (>50 mm) 4 = pith included*



of material graded as MGP 10. While these sectional comparisons indicate less efficient utilisation of whitewood, it is noteworthy that large sections offer opportunities to utilise the pith by sawing this defect into single boxed sections fully enclosing the pith, and the impact of larger knot defects can be more readily accommodated in large sections. Further research is required to establish mechanical properties in these large sizes to develop building design specifications using knotty structural whitewood.

Whitewood has low durability to biological degradation, but will readily take chemical preservative treatment (Groves and Wood 1998). This capacity represents a significant opportunity to add value to whitewood in Vanuatu, since outdoor and in ground products may be produced from any part of a log. Figure 5 illustrates that good penetration of preservative (Tanalith E) can be achieved into whitewood sapwood and heartwood. The end sections shown are from a piece 100 mm × 100 mm × 1 m long, cross cut at its mid-point. The pith is evident as a small circular section near the top of the image and is surrounded by heartwood. Irregular penetration of preservative is indicated by wood of lighter green colour. The sample shown was selected as the poorest penetration pattern achieved amongst six samples. Further research is required to test the efficacy of this preservative treatment in service.

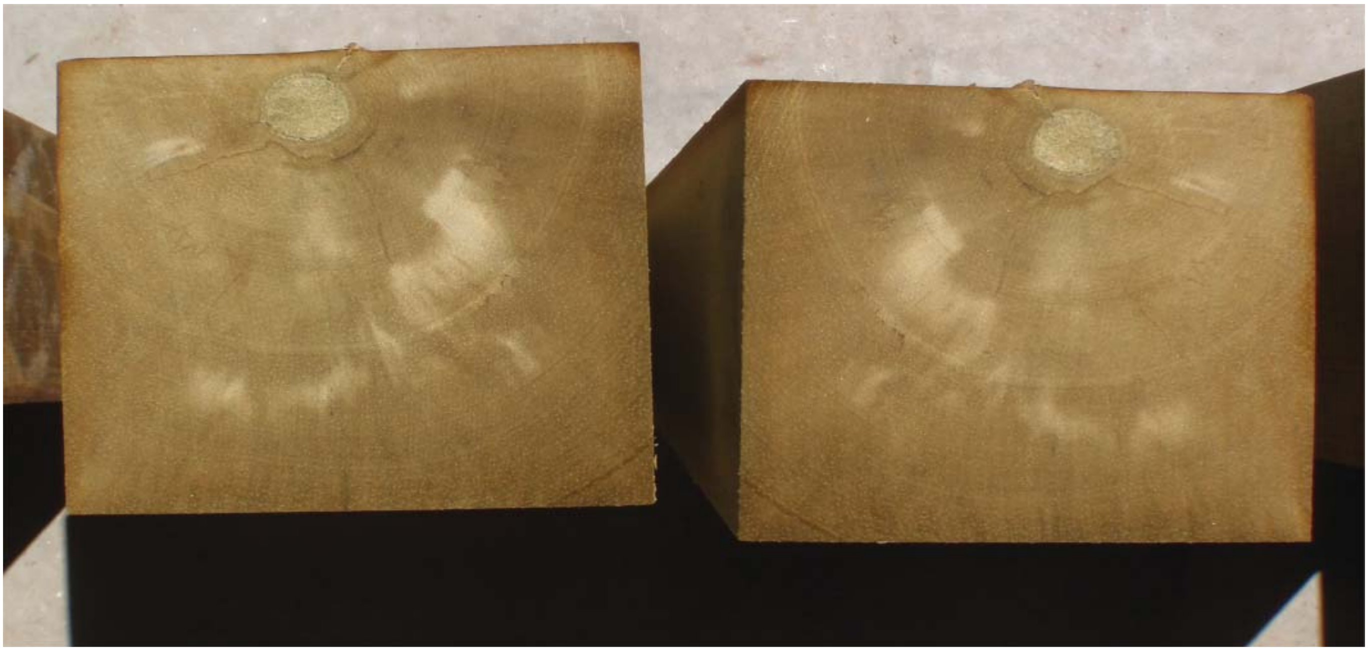
DISCUSSION AND CONCLUSION

The study illustrates the importance of recovering value from knotty and pith-included wood, which comprise over 65% of the wood sawn from plantation logs. Two options for utilising this knotty wood are to develop structural products, and to produce short clear lengths for furniture manufacturing. The potential of structural products depend on the mechanical properties of large-section sawnwood, on strength sorting technology and on the provision of engineering and design information for builders. Technical aspects need to be accompanied by an education program for wood users and building material suppliers so that they are adequately informed about structural strength, timber durability and degradation.

The development of a whitewood production and processing industry will also depend on expanding processing capacity to achieve economies of scale. At present the processes that add greatest value are air drying and preservative treatment. The latter are not easily achieved in a portable saw mill context and require significant investment in infrastructure. Nonetheless, at a small scale wood can be protected from borers and blue stain by spraying and dip diffusion of preservative chemicals for interior use. Exterior and ground contact uses demand pressure and vacuum processes to ensure effective treatment.

This study has revealed a lack of resource base to supply the whitewood production and value-adding processing industry in Vanuatu. Successful establishment of a small-scale resource has been achieved, but a larger-scale resource is needed before significant domestic and export markets can be redeveloped or investment into value-adding process infrastructure can be attracted. Softwood imports remain relatively

FIGURE 5 *Penetration of copper based preservative (Tanalith E.) into the heartwood of whitewood*



small (5,000 m^3 in 2011) and former exports of whitewood (3,000 m^3 in 2003) reveal the potential for a larger processing industry. The primary challenges in the short term to secure sufficient plantation resource near processing facilities, and to develop in-field pre-processing to facilitate efficient transport of wood for final processing in centralised plants.

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