

# Objective 1.1

## Market assessment and product development

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### Coconut Veneer project

*Development of advanced veneer and other product from coconut wood to enhance livelihoods in South Pacific communities*



Australian Government  
Australian Centre for  
International Agricultural Research



UNIVERSITY of  
TASMANIA



Queensland  
Government



SPC  
Secretariat  
of the Pacific  
Community

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## Executive summary

High quality and high density coconut veneer and veneer-based product are new to the marketplace. Their likely acceptance can only be estimated from observation of the material's properties, the performance requirement of potential applications, and the acceptance of similar (or competitor) products in those applications in the market.

The form and material properties of coconut palms significantly influences the potential functionality of recovered coconut wood and veneer products. The distribution of vascular bundles and the resultant density variation of the material optimizes the stability of the standing palm but makes the stem a very uneven resource with uneven physical properties for processing into consistent and useful products for markets.

Given these realities and the responses supplied by design professionals and wood products manufacturers to market assessment interviews, coconut veneer's competitive advantages in the market appear to include:

- The hardness/density of the outside of the stem. With density greater than  $700 \text{ kg/m}^3$ , this material should be generally acceptable for heavy commercial floor traffic where densities above  $650 \text{ kg/m}^3$  are generally accepted for true timber species.
- The visual consistency of individual sheets. They have a mottled, lively texture to the surface.
  - Traditional timber 'features' are absent, providing an even but lively surface appearance.
  - The look has characteristic 'brand' recognition for tropic areas and tourist facilities.
- A relatively narrow colour range, being mainly straw to mid and dark browns.
  - Yellow or red browns are rare.
- A graduation in colour from dark to light.
- The potential for reassembling veneer into sizes larger than can be recovered by sawing coconut stems.
  - Sawn sections are generally narrow (75 - 100mm). They can also be unstable.
- Log supply is available, given the volume of standing senile stems.
- Supply has a clear environmental message.
  - The material is indisputably from a plantation resource and palm replacement has positive connections to ongoing agricultural productivity and community self-reliance and well-being.

Coconut veneer's competitive disadvantages in the market appear to include:

- A relatively narrow colour range that limits design diversity.
- The visual liveliness of the material.
  - The smooth grain, texture, and colour patterns of high quality species are missing.
- A tendency to split during processing and handling, particularly in thin sheets. This creates several complications in design and assembly.
  - To ensure suitable sheet resilience, the standard production thickness of coconut veneer is likely to be thicker than conventional appearance hardwoods and softwood veneers. Because of this, coconut veneer will not be a 'like-for-like' replacement for these veneers in design selections or in fabricator assembly.
  - The final thickness of coconut veneer on boards may create jointing and matching difficulties during assembly of items that incorporate coconut and true wood veneers in the same piece.
- A naturally rough surface finish to the dry veneer. This generates the need for additional care during gluing and sanding of the final product.
- A relatively low average MOE compared to most commercial wood species.
- Low shear strength, given the longitudinal nature of the vascular bundles and the poor structural properties of the inter-bundle matrix.
- Relatively low average structural characteristics that imply that lower strength material will not be particularly useful for structural applications.

Design of coconut-veneer based veneer products would seek to exploit these competitive advantages while pursuing construction strategies to moderate the disadvantages.

## Product potential

These competitive realities suggest a range of possible product utilities, shown in

Table 1. Utilities are estimates of likely profitable production and supply to the target market. In the table, density is used as a surrogate for other properties necessary for the target application.

**Table 1: Likely utility of coconut veneer in applications and products**  
(HD= density > 600 kg/m<sup>3</sup>, MD= density 400 - 600 kg/m<sup>3</sup>, LD= density < 400 kg/m<sup>3</sup>)

Application	Likely high utility	Likely medium utility	Likely low utility
Flooring	✓ HD, MD for sheet ply flooring or overlay on substrate.		
Lining	✓ HD, MD, LD for veneered board or ply		
Joinery surfaces (sides)		✓ HD, MD, LD for veneered board or ply	
Joinery surfaces (tops and solids)	✓ HD, MD for veneered board, ply or LVL		
Bench tops	✓ HD, MD for ply or LVL		
Architectural structures		✓ HD, MD for LVL	
Form ply			✓ HD, MD for face veneer
Structural ply (Face material)			✓ HD, MD for face veneer
Structural ply (core material)		✓ HD, MD, LD	
LVL			✓ HD, MD
Specialist light plywood	✓ LD with HD face veneer.		

## Introduction

This report discusses the market assessment and potential from products assembled from peeled coconut veneer and supplied to market. It is based on

- Initial findings of market preferences and requirements from market surveys of designers and industry producers.
- Confirmation of the material properties from testing and product experimentation.
- Discussions with timber and wood product importers and marketers.

It forms part of the ACIAR funded CocoVeneer project: *Development of advanced veneer and other products from coconut wood to enhance livelihoods in South Pacific communities*. The participating research organisations in the project are the University of Tasmania's Centre for Sustainable Architecture with Wood (CSAW) and the Queensland Department of Agriculture and Fisheries (QDAF) Innovative Forest Products Team, with Pacific Community (SPC) as the principal partner country collaborator. The Fiji Department of Fisheries and Forestry, the Samoan Ministry of Natural Resources and Environment, and the Solomon Islands' Ministry of Forestry and Research are also partner country collaborators.

### **Material uses in a market**

High quality and high density coconut veneer and veneer-based product are new to the marketplace. Their likely acceptance can only be estimated from observation of the material's properties, the performance requirement of potential applications, and the acceptance of similar (or competitor) products in those applications in the market.

Any material derives usefulness, value and marketability through the functions it can perform economically (Marra 1972). Functions are performed mainly through the:

- Sizes, shapes and appearances into which the material can be converted.
- Physical tasks that it can do.

The material's properties strongly influence the functions that can be performed.

Most building materials are manufactured through transformative production processes. The conversion of iron ore to steel and oil to plastic are examples. In these cases, the properties of the output can be manipulated within given bounds to ensure the material performs specific functions.

However, wood products and other renewable materials such as coconut wood and veneer are made through reductive processes. In reductive processes, the form of the base resource significantly influences the size, shape and appearance of the recovered pieces. Similarly, the material properties of the base resource are retained in the recovered products and significantly affect their performance.

In summary, the resource's form and material properties critically influence the functions that the recovered material can usefully perform.

### **Coconut wood and veneer as 'wood' products**

As discussed in greater detail below, coconut wood or veneer is the name given to the material recovered from the stem of the coconut palm, *Cocos nucifera*. Technically, it is not true wood and has significantly different properties and cell arrangement to wood from commercially processed tree species. However, in practice, the market tends to regard sawn coconut wood and peeled veneer broadly as wood products and a direct competitor with other wood products. Impressions and assumptions about wood products will broadly apply to coconut wood products and their performance, and, like most wood products, the major markets for coconut veneer products are likely to be in building construction: in the structure and surfaces of building components, and in associated joinery and furniture.

### **Report structure**

This report discusses:

- Coconut's material properties.



- This summaries information primarily from two key references: Killman et al. (1996) and Bailleres et al. (2010).
- Market opportunities for products in major market sectors. This includes:
  - The key performance requirements for products in each sector.
  - A summary of initial market assessment conducted by UTAS and QDAF, and the results of further industry discussion.
  - Commentary on these assessments given increased understanding of the properties of coconut veneer.
- Market advantages and product potential for coconut veneer

The methodology and results from the initial UTAS and QDAF market assessments are included in Appendices 1 and 2 for UTAS and Appendix 3 for QDAF.

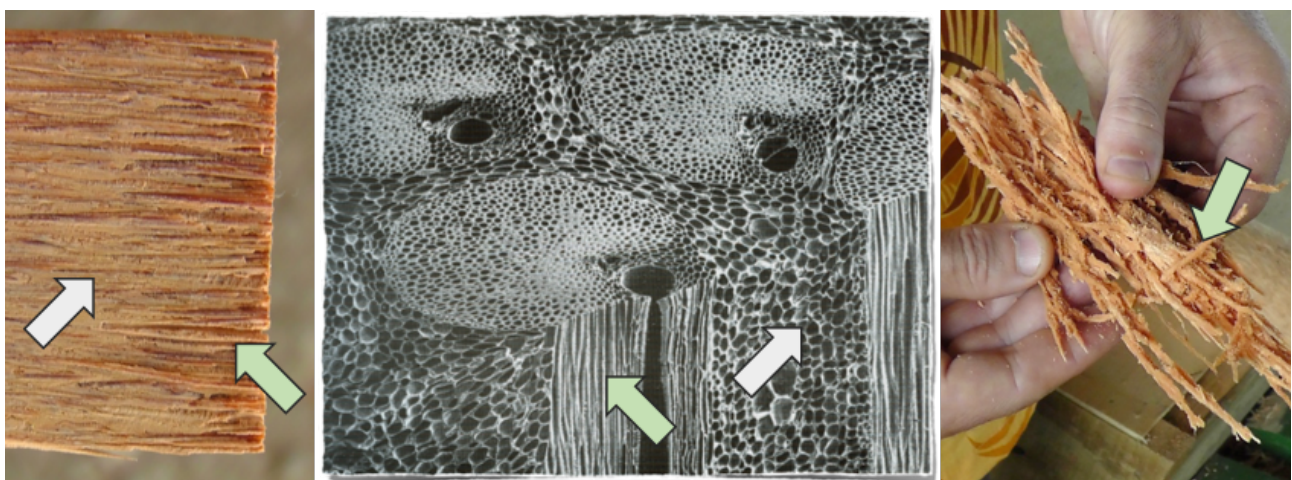
## Coconut's material properties

As discussed in detail in Killman et al. (1996) and Bailleres et al. (2010), coconut wood is the name given to the material recovered from the stem of the coconut palm, *Cocos nucifera*. Technically, it is not true wood. Botanically, *C. nucifera* is a monocotyledon and the properties of its 'wood' and the arrangement of its cells are significantly different to the properties and cell arrangement found in the wood of softwood and hardwood tree species.

The wood in coconut palm has two major components: distinct longitudinally arranged, often dark red-brown, high density vascular fibre bundles and a yellowish, low density ground tissue in which the bundles are scattered (Killman et al. 1996). See Figure 1. The bundles contain the water and nutrient transport system of the plant as well as thick-walled and dense vascular fibres that give the stem its strength. By comparison, the ground tissue is relatively soft and weak.

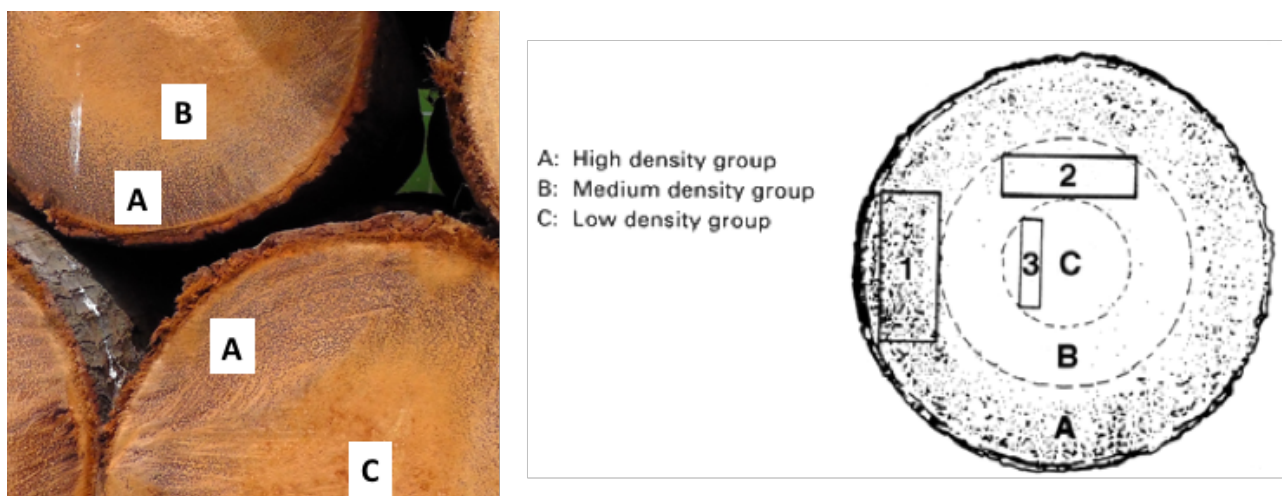
Coconut wood lacks the structure of ray cells found in true wood, leaving a material whose characteristics are dominated by the number, arrangement and character of the vascular bundles in section and longitudinally.

The distribution, cross section, tensile strength and colour of the vascular bundles varies with their location in the stem. The distribution of vascular bundles and the resultant density of the material vary both across the section and up the height of the coconut stem. From the outside of the stem to its centre, density can vary from greater than 700 kg/m<sup>3</sup> in material in a hard perimeter band, from 500 – 700 kg/m<sup>3</sup> in a middle band to less than 400 kg/m<sup>3</sup> in the soft inner core. See Figure 2. In the base logs of older, senile palm, the density of the hard perimeter band can be greater than 800 kg/m<sup>3</sup>. Average densities across the stem also reduce going up the stem. The character of the vascular bundles also varies with their location. The vascular bundles in the dense outside band of the stem have a higher cross section, greater tensile strength (Fathi and Frühwald 2014) and appear to be a darker colour than those closer to the centre.



**Figure 1: Distinct vascular bundles (green arrow) and pale ground tissue in and coconut veneer, a microscopic photo of coconut (Bailleres et al. 2010) and crushed coconut fibre.**

These variations in cell arrangement and characteristics optimize the stability of the palm as a tall thin column but makes the stem a very uneven resource with varying physical properties for processing into products.



**Figure 2: Cross section of coconut palm stem with density zones (adapted from Killman 1996 Fig. 3)**

### **Strength and other mechanical properties**

Some mechanical properties of coconut wood are summarised in Table 2 and Table 3. The modulus of elasticity (MOE) of the material varies from 11, 400 MPa for the high-density coconut material to only 3,600 MPa for the low density material. As a comparison, Bootle (2005) lists the MOE for radiata pine (*Pinus radiata*) at 10,000 MPa and for Blackbutt (*E. pilularis*) at 19,000 MPa.

### **Density**

Density is a key physical property of timber and other wood products. In general terms, it is a reliable indicator of strength, stiffness, joint strength, and hardness (NAFI 2004).

As discussed above, the density of coconut wood regularly ranges from greater than 700 kg/m<sup>3</sup> for material on the outside of senile stems to less than 400 kg/m<sup>3</sup> for material in the stem's centre. By comparison, Bootle (2005) lists the density of radiata pine (*Pinus radiata*) as 500 kg/m<sup>3</sup>, Messmate (*E. obliqua*) at 780 kg/m<sup>3</sup> and Blackbutt at 900 kg/m<sup>3</sup>.

**Table 2: Mechanical properties of Coconut wood (from Killman et al. 1996)**

Basic density (g/cm <sup>3</sup> )	0.25 - 0.39	0.4 - 0.59	>0.6
<b>Strength (MPa)</b>			
Modulus of elasticity	3633	7116	11414
Modulus of rupture	33	63	104
Compression parallel to grain	19	38	57
Shear	n.a.	8	13

Source: Sutc, 1983, 3

**Table 3: Mechanical properties of coconut wood (from Bailleres et al. 2010 p. 15)**

<b>Mechanical properties (units)</b>	<b>Range = low–high density fibre</b>
Modulus of elasticity: dry (GPa)	2- 25   high density: 11.4
Modulus of rupture: dry (GPa)	28 - 205   high density: 104
Maximum crushing strength: dry (MPa)	19 - 57   high density: 40
Janka hardness: dry (kN)	0.7 – 23.9



### ***Implication of material properties on board and veneer production***

The variability of material properties in the coconut stem influences the relationship between product recovery and sawn board performance after recovery. To achieve an even density through a board, the stem has to be 'backsawn' within relatively narrow bands of material. See Figure 2. As a result, only relatively narrow and thin boards have limited density variation. Wide boards inevitably have significant density variation and tend to distort. This is particularly the case for wide boards from senile stems. Bailleres (2010) noted other production implications:

- Enhanced spiral grain makes the boards liable to degrade through twist.
- Distortion can be exacerbated by variation in density and grain alignment within a small cross section area.
- Cocowood fibre is very hygroscopic. That is, it absorbs and gives off moisture readily to be in equilibrium with its surrounding environment.

Coconut's material properties also influence the product recovery and utility of the veneer, particularly through limitations on veneer thickness, sheet brittleness, natural surface roughness and variation in veneer density along the ribbon.

With true woods, veneer is commonly produced by:

- Slicing a sawn flitch with a blade to producing veneer of thickness from 0.4 mm.
- Rotary peeling a log on a lathe to produce veneers of thickness from about 1.0 mm.

The veneer's intended application influences its target thickness in production. Appearance wood veneers are generally cut thin, at thicknesses of 0.6 to 1.0 mm, to maximize the recovery of the material's desirable characteristics. This type of veneer is then often adhered to a substrate before use. Structural veneer is commonly peeled at thicknesses between 2.0 and 3.6 mm and then laminated together to form plywood, laminated veneer lumber (LVL), or similar products.

Coconut wood's material properties restrict its potential to be successfully converted into thin veneer sheets. The properties of the vascular bundles compared to the ground tissue, the bundle's prominent longitudinal direction and the lack of radial or connecting cells in the inter-bundle matrix reduces the veneer's strength across the sheet compared to true wood veneer and make it brittle. A minimum sheet thickness of at least 2 mm is needed to maintain veneer quality (Bailleres et al. 2015). As coconut veneer can be brittle, careful handling is needed of the sheets and of veneer edges. As shown in Figure 1, the soft ground tissue can come away from harder vascular bundles, especially in dry material.

As noted in McGavin and Bergmaier-Masau (2016), the veneer produced from coconut stems was expected to have a rougher surface than what is generally produced in the traditional wood veneer processing industry. This was confirmed in project trials where a roughness score of 3 dominated the assessment indicating that the veneers would be expected to be made smooth after moderate sanding. This is a result of the unique structure of the coconut stem but can complicate production, particularly in achieving reliable glue bonds.

While the density along the veneer ribbon recovered from true wood will vary marginally, the density and often the colour of the veneer from a coconut stem varies considerably along the length of the veneer ribbon. Higher density veneer will be produced initially and this reduces quickly along the ribbon. Coconut veneer will need to be sorted into density groups, and discrete products will need to be considered for each group.

### ***Visual character and colour***

Coconut wood has important visual differences to true wood. Coconut's visual character is largely influenced by the pattern of its vascular bundles exposed on the face of the sheet: their colour, frequency and angle of cut. Coconut wood lacks the growth rings, gum vein, knots or other visual features common in normal timber.

Coconut has a relatively narrow range within the colour spectrum but colour intensity ranges from straw to mid and dark browns. Vascular bundle colour can vary from dark brown and almost black in the stem's high density band to pale straw towards the centre of the stem. The colour of the

ground tissues between the bundles can also vary. As a result, the higher the number of vascular bundles, broadly the darker the overall board or sheet colour will be while the material from the centre of the stem with a lower number of vascular bundles will be paler. Coconut lacks the colour diversity found in true woods, which can vary from yellow, to red and orange browns, and charcoal brown.

Without normal wood features, peeled coconut veneer has generally consistent visually characteristics across the sheet, with distinct longitudinal grain and regular, generally coarse colour variation. This gives a mottled, lively texture to the surface. See Figure 3. While lively, the large piece size of veneer provides a much more consistent overall appearance than coconut wood board in applications such as flooring or wall lining.



**Figure 3: Varied visual character of coconut veneer.**

## Market opportunities

Generally, market opportunities exist for any materials whose performance can efficiently and economically satisfy the performance requirements for an application. As coconut veneer is a new product in the market, the key question is then which performance requirements can it efficiently and economically satisfy?

In practice, the market tends to regard sawn coconut wood and veneer broadly as wood products and a direct competitor with other wood products. In Australia, most wood and wood-like products are used in the building and related construction market in items such as the structure and surfaces of building components, and in associated joinery and furniture. The major segments of these markets are appearance and structural applications. To be selected regularly, the material then has to be available through a reliable supply chain.

### ***Appearance applications***

Appearance applications are those where a material's visual appeal to designers is a critical factor in its selection. They include flooring applications, lining, joinery surfaces, bench tops, and elements used in architectural structures such as exposed roof beams and columns. The highest value coconut veneer products are likely to be those used in appearance applications. Interior architectural panels can achieve approximately double the wholesale price of structural panels. For example, high-grade plantation hoop pine achieves prices up to about \$2,200/m<sup>3</sup> compared with the price for best quality formply at about \$1,000/m<sup>3</sup>.

Appearance applications are subject to the changing demands of fashion but material successfully used in this segment often has unique characteristics and can be viewed as a differentiated product. The key wood properties critical for appearance applications for veneer-based products are colour, colour consistency, other visual aspects such as grain and feature, and critical aspects of functionality such as the sheet stability, hardness, durability, and veneer workability.

### ***Structural applications***

Structural applications are those where a material's structural performance (MOE, MOR, etc) and price are critical selection factors. These applications include structural framing, bracing and form

plywood and laminated veneer lumber (LVL) concealed under other lining and finishes. Structural applications are highly competitive as the performance and price of materials are regularly compared and mobility between solutions can be high if price differentials develop. To compete, structural products tend to be produced and marketed as commodities. The key wood properties critical of veneer for structural applications are stiffness, strength, glue-ability, stability, workability, and for external applications, durability. Critical aspects of functionality such as weight are also important.

### **Supply chain reliability**

To be credible in the marketplace, the supply chain for coconut veneer products need to be established and then develop sufficient reliability to assure customers that a regular supply of material, sorted to an accepted grade, can be delivered, preferably from more than one supplier.

### **Market potential: appearance product**

Product development requires matching the performance requirement of applications with the likely performance for coconut veneer-based products. The major groups of appearance veneer-based products are:

- Veneer overlays on one side of a ply or fibreboard substrate.
- Veneer laid on two sides of a substrate for joinery and other applications.
  - This is also known as veneered board.
- Appearance grade plywood of various thicknesses.
- Appearance grade laminated veneer lumber (LVL).

Construction strategies for assembling plywood and LVL can be designed to improve their appearance or structural performance in target applications. This can include manipulating the resource used and the way it is assembled in a sheet or panel. For example:

- Coconut veneer can be matched by a target characteristic such as colour and density and then products assembled from or across batches to optimise performance and appeal.
- Coconut veneer and veneer from other species can be blended in a product.
- LVL and plywood blocks and panels (also known as multilaminar blocks) can be assembled from batched or blended material and then resawn into other products. For example, LVL can be resawn into structural elements larger than those available by sawing coconut.

Key performance requirements for major appearance application and observations on the possible use of coconut veneer product are listed in Table 4.

**Table 4: Performance requirements and potential products for appearance applications**

<b>Appearance application</b>	<b>Key performance requirements</b>	<b>Potential products</b>	<b>Possible product and observations</b>
Flooring	Surface hardness is important, particularly for commercial applications.  Densities above 650 kg/m <sup>3</sup> for true timber species are generally accepted for commercial floor traffic.	Veneer overlay on a substrate.  Appearance plywood sheet flooring.	High-density veneer would be generally suitable for the surface of commercial flooring products.  High - mid-density veneer would probably be suitable for light commercial and domestic applications.
Lining	Colour consistency and board stability is important.	Appearance and a balancing veneer on a substrate.  Appearance plywood.	All veneer types would generally be suitable

Appearance application	Key performance requirements	Potential products	Possible product and observations
Joinery and furniture surfaces (sides)	Colour consistency and board stability is important.	Appearance veneer on two sides of a substrate. Appearance plywood. Appearance LVL.	All veneer types would generally be suitable.
Joinery and furniture surfaces (tops and solids)	Higher impact and abrasion resistance is desirable on wearing surfaces. Colour matching with joinery sides is important.	Appearance veneer on two sides of a substrate. Appearance plywood Appearance LVL.	High to mid-density veneer would generally be suitable.
Bench tops	Higher impact and abrasion resistance is desirable on active wearing surfaces. Surfaces may be regularly wet.	Veneer overlay on a high-moisture resistant substrate. Appearance plywood. Appearance LVL.	High to mid-density veneer would generally be suitable.
Architectural structures	High MOE important for LVL to minimise required section size.	Appearance plywood. Appearance LVL.	MOE related to density.

### **Colour and surface texture**

Colour and surface texture are important characteristic of any material selected for appearance applications. Given the colour intensity range in coconut veneer, it is highly likely the material sold for appearance applications will be graded for colour and used with its natural colour or stained to a consistent tone.

As part of the initial market assessment of the material, UTAS designers grouped coconut samples into three colour batches: light, medium and dark and sought designer comment on the desirability of each. A questionnaire and colour-graded samples of cocowood veneer were sent to twenty-one designers and plywood manufacturers & retailers. Seven responses were collected and are summarised in Table 5. Full results are included in Appendix 2.

Respondents were asked to rate particular aspects of colour-graded coconut veneer samples on a 1-5 scale where 1 was not useful or unimportant, and 5 was very useful and very important.

**Table 5: Rating of aspects of coconut veneer by colour**  
(1=not useful, unimportant, 5 =very useful, important)

	Appearance	Design potential	Joinery Suitability	Lining suitability	Engineered flooring suitability	Availability of solids that match the veneer
Sample 1-Dark	3.8	4.0	3.4	3.0	3.5	3.6
Sample 2-Mid	3.4	3.8	3.6	3.2	3.5	3.4
Sample 3-Light	3.6	3.6	3.6	3.4	3.6	3.6

There is reasonably consistent scoring across the three colour batches, suggesting a potential appearance market for the light coloured (and generally less dense) veneer as well as the darker (and often more dense) veneer.

During later assessment, UTAS designers identified 5 distinct colour groups across two packs of coconut veneer. Surface texture also varied between these groupings. While these packs were not representative of full coconut veneer production and the material was sorted subjectively, this exercise identified that:

- Discrete and cohesive colour and texture groups could be established for coconut veneer sheets.
- Each group is likely to have varying appeal for designers in applications.



- The boundaries for colour groups could be established to match both with the properties of the local resource and varying demand from design markets.

### ***Requirements for fire performance***

Most regulatory regimes for buildings internationally include requirements for the performance of materials in the event of fire. Generally applying to lining, flooring, and similar applications in buildings, these requirements limit the propensity of materials to burst into flame, generate smoke, or cause other hazards to occupants while buildings are being evacuated. For example, Australia's National Construction Code requires particular fire indices for materials used in exposed surfaces of Class 2 to 9 buildings. Assuming appearance coconut veneer will be exported for use in the exposed surfaces of building, the fire indices for coconut wood solids and veneers would need to be determined through accredited material testing.

### ***Environmental and social credentials***

Environmental credentials and recognition in the marketplace are important aspects of building demand for coconut wood and veneer products. Several respondents to the initial market assessment noted this, adding that certified coconut veneer would have good green/environmental credentials, and be a suitable substitute environmentally for rainforest veneers.

Environmental credentials for wood products internationally fall into three main types: market assurance of environmental responsibility, legality of supply, and forest certification. Market assurance is an informal credential that is based upon the material's public image. As coconut veneer products are value recovery products from an agricultural plantation produced in under-developed countries, they have a ready-made marketing narrative for environmental and social responsibility. The material is indisputably from a plantation resource and palm replacement has positive connections to ongoing agricultural productivity and community self-reliance and well-being. The existence of harvesting and site rehabilitation guidelines supports this narrative. Such narratives could underpin campaigns to build market perceptions that the products are environmentally responsible.

Legality of supply is a required credential for the import of wood products into Australia and similarly regulated economies. However, as there are currently few legal requirements for the harvest of coconut trees, this criterion can be readily met.

Forest certification is the only form of environmental credential recognised internationally. It involves both forestry and chain-of-custody (CoC) certification against the standard of an environmental certification scheme by a third-party certification agency. As a demonstrable plantation product, the certification of coconut wood and veneer products is conceptually straightforward. However, the procedures needed to establish formal certification in a company or supply chain are expensive and organisationally difficult to achieve, operate and maintain. Of the current project participants, only the Value Added Timber Association (VATA) in the Solomon Islands had CoC certification in place for exported board products but this has lapsed.

### ***Form of supply, workability and pricing of appearance products***

Coconut veneer's unique characteristics will influence how it is traded internationally. Appearance veneer and veneer products are traded in several forms including assembled plywood or LVL products and graded veneer sheets prepared for laying (or adhering) onto substrates.

Plywood and LVL products are usually made in facilities whose staff have experience with coconut veneer's particular handling and finishing requirements. As exported products, this material will require careful but not extraordinary handling.

Graded veneer sheets may be different. Veneered board is a common product in many markets but rarely traded over long distances. To constrain cost and storage requirements, veneer distributors prefer to either:

- Supply veneer sheets directly to joiners who adhere it to substrates as required.
- Lay veneer sheets directly onto the required substrates and supplied them to customers as finished, sanded products ready for further fabrication.

This has implications for the supply and acceptance of appearance coconut veneer sheets. Veneer distributors and joineries use regular sizes of sheet material and expect particular level of performance from veneer sheets. They will naturally compare the working properties of coconut veneer with other available wood veneers. Their expectations will include:

- Standard industry sizes for laying onto panels or laminating into plywood. Lengths are usually 1.8, 2.4, 2.7 and 3.0 m and width of 0.9 and 1.2 m;
- Regular and low moisture content.
- Veneer supplied flat with a smooth face and no wavy edges.
- Veneer rugged enough to survive handling without failure.
- Veneer thickness comparable with other veneer products.

The first three of the points above can be handled through maintaining suitable quality production. However, the brittleness and necessary thickness of coconut veneer are likely to be issues with veneer distributors and joiners. Brittleness can be addressed by applying an economical fleece backing to high quality sheets.

However, coconut veneer's minimum 2mm thickness means that it cannot be used as a direct replacement for another selection in a design and can create complications in design and joint assembly, especially when coconut veneer is combined with timber veneers in a design. For example, in a design that includes alternate coconut and timber veneered shelves, the shelves of each type may end up at different thickness and weights. Assuming an 18 mm substrate for all shelves, two layers of 0.6 mm timber veneer will sand to a finished shelf thickness of 19 mm. The coconut veneered shelves will have two thicknesses of nominally 2.4 mm veneer for a 22.5 mm finished sanded thickness. This 3.5 mm variation in thickness is a noticeable, and usually undesirable complication. Jointing and some hardware fit-off complications may also arise.

Indicative prices given include: bamboo products that range from \$5-\$10/m<sup>2</sup> for general veneers up to \$30/m<sup>2</sup> for A grade bamboo; A grade hoop pine at \$2,200/m<sup>3</sup> and A grade birch \$1,500/m<sup>3</sup>.

### ***Other respondent comments***

Respondents to the market assessment survey identified other market support requirements, including: bonding compatibility (gluability) guidance for cabinetry and fine furniture, coating and finishing system instructions/technical data, screw holding capacity, moisture movement information, the material's ability to take a stain and a high finish. Advice on many of these points is included in other project reports.

Other respondent comments and observations on appearance applications included:

- ✓ Pleasing, exotic appearance is an asset.
- ✓ Good potential for niche markets.
- ✓ Thicker veneers may command a premium in the joinery market (allows sanding and redressing)
- ✓ A very dark brown would be desirable.
- Niche appearance markets will not be high volumes.
- Grading should include bundle frequency as well as colour.
- X Current fashion is for plain veneer or melamine. Material will be colour matched.
- X Current market acceptance and expectation for appearance veneer is for 'thin' veneer (0.4 to 1.0mm).

### **Market potential: structural products**

Key performance requirements for major appearance application are listed in Table 6. The major groups of structural veneer-based products are:

- Structural plywood of various types and thicknesses.
- Laminated veneer lumber (LVL).



**Table 6: Key performance requirements for major structural applications**

Structural application	Key performance requirements	Observations
Form ply	Predictable mechanical properties (MOE, MOR, shear, etc) preferably superior to competitor materials such as radiata pine, hard and smooth, indentation resistant surface, limited weight.	High-density coconut veneer could provide the hard surface layer but it is thicker than hardwood veneers currently in use. The thicker coconut veneer may increase overall sheet thickness and weight to achieve the target MOE.
Structural ply (Face material)	Smooth finish, predictable preferably high MOE, MOR and shear, reliable gluing, competitive price and regular supply.	High and mid-density veneer could provide face veneer but shear values may be an issue.
Structural ply (core material)	Predictable MOE & MOR, reliable gluing, low price.	Depending on the place in the core, all veneer types could be suitable.
LVL	Predictable, preferably high MOE, MOR and shear, reliable gluing, competitive price and high levels of supply.	High and mid-density veneer could provide suitable strength but shear values may be an issue. Also high production volumes could be unrealistic for material solely assembled from coconut. Blending coconut with other material may be suitable.
Specialist light plywood	Preferably high MOE, MOR and shear from lightweight material, competitive price and regular supply.	Potentially suitable for low-density veneer but strength and shear values and veneer thickness may be an issue.

### ***Sizing and price***

Sizes and workability issues for structural veneer used for plywood and LVL include:

- Standard industry sizes for laminating into plywood - lengths: 1.8, 2.4, 2.7 and 3.0 m; width 0.9 and 1.2 m;
- Veneer being supplied flat with a smooth face and no wavy edges.
- The veneer being rugged enough to survive handling without failure.
- Low moisture content.

Wholesale prices information provided included: general structural panels \$500/m<sup>3</sup>; formply \$500-\$1000/m<sup>3</sup>; bracing ply \$650/m<sup>3</sup>; hardwood panels with mid to low quality face veneer \$650/m<sup>3</sup> FOB

Other respondent comments and observations include:

- Veneer could work well laid onto other core material
- X Form-ply face veneer currently 1.0 to 1.5mm thick
- X New species/products are slow to be accepted into construction

## Market advantages and product potential

The form and material properties of coconut palms significantly influences the potential functionality of recovered coconut wood and veneer products. Given these realities and the responses supplied by design professionals and wood products manufacturers, coconut veneer's competitive advantages in the market appear to include:

- The hardness/density of the outside of the stem. With density greater than 700 kg/m<sup>3</sup>, this material should be generally acceptable for heavy commercial floor traffic where densities above 650 kg/m<sup>3</sup> are generally accepted for true timber species.
- The visual consistency of individual sheets, with a mottled, lively texture to the surface.
  - Traditional timber 'features' are absent, providing an even surface appearance.
  - The look has characteristic 'brand' recognition for tropic areas and tourist facilities.
- A relatively narrow colour range, being mainly straw to mid and dark browns.
  - Yellow or red browns are rare.
- A graduation in colour from dark to light.
- The potential for reassembly into sizes larger than can be recovered by sawing.
  - Sawn sections are generally narrow (75 - 100mm) or unstable.
- Log supply is available, given the volume of standing senile stems.
- Supply has a clear environmental message.
  - The material is indisputably from a plantation resource and palm replacement has positive connections to ongoing agricultural productivity and community self-reliance and well-being.

Coconut veneer's competitive disadvantages in the market appear to include:

- A relatively narrow colour range that limits design diversity.
- The visual liveliness of the material. The smooth grain, texture, and colour patterns of high quality species are missing.
- A tendency to split during processing and handling, particularly in thin sheets. To ensure suitable sheet resilience, standard coconut veneer thickness will be thicker than material currently supplied to the market.
  - Because of this, coconut veneer will not be a 'like-for-like' replacement for these veneers in design selections or in fabricator assembly.
- The final thickness of coconut veneer on boards may create jointing and matching difficulties during assembly of items that incorporate coconut and true wood veneers in the same piece.
- A naturally rough surface finish to the dry veneer. This generates the need for additional care during gluing and sanding of the final product.
- A relatively low average MOE compared to most commercial wood species.
- A low shear strength, given the longitudinal nature of the vascular bundles and the poor structural properties of the inter-bundle matrix.
- Relatively low average structural characteristics that implies that lower strength material will not be particularly useful for structural applications.

### ***Product potential***

These competitive realities suggest a range of possible product utilities, described below and shown in Table 7. In this table, density is used as a surrogate for other properties necessary for the target application.

- High utility in appearance applications is based on a visually active palette, especially those where hardness is a key performance requirement. These could include:
  - Appearance face on wall lining products.
  - Appearance face on overlay or sheet flooring products.
  - Large-scale solid material such as plywood, LVL and multilaminar sections in colour matched or colour contrasting combinations.
- High utility in architectural application with a strong environmental or tourist agenda.
  - Supply avoids any suggestion of contentious forestry issues, is from a plantation, and coconut stem renewal supports a development agenda.

- Coconut wood has distinct visual characteristics, directly aligned with tropical locations.
- Medium utility in industrial applications where surface hardness is important.
- Medium utility as the inner bands and possibly surfaces of general interior and furniture ply.
- Medium to low utility in structural applications due to MOE, MOR and shear constraints.
  - Placing this material on the outside face of structural products such as formply can significantly reduce the effective MOE of the resultant board, as a relatively weak material will be positioned in the location with the highest stress. This will require a thicker board to achieve the same performance and result in a heavier product. Weight is already a workplace health and safety issue with formply on construction sites in Australia and similar economies.
  - With increasing pressure on log supply overall, coconut veneer can contribute to the stock of material available for use in blended-species structural products.

**Table 7: Likely utility of coconut veneer in applications and products**  
 (HD= density > 600 kg/m<sup>3</sup>, MD= density 400 - 600 kg/m<sup>3</sup>, LD= density < 400 kg/m<sup>3</sup>)

Application	Likely high utility	Likely medium utility	Likely low utility
Flooring	✓ HD, MD for sheet ply flooring or overlay on substrate.		
Lining	✓ HD, MD, LD for veneered board or ply		
Joinery surfaces (sides)		✓ HD, MD, LD for veneered board or ply	
Joinery surfaces (tops and solids)	✓ HD, MD for veneered board, ply or LVL		
Bench tops	✓ HD, MD for ply or LVL		
Architectural structures		✓ HD, MD for LVL	
Form ply			✓ HD, MD for face veneer
Structural ply (Face material)			✓ HD, MD for face veneer
Structural ply (core material)		✓ HD, MD, LD	
LVL			✓ HD, MD
Specialist light plywood	✓ LD with HD face veneer.		

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# Appendix 1: Market assessment questionnaire

## Methodology

Early in the project, CSAW and QDAF conducted separate market surveys using questionnaires developed to target either designers or engineered wood product manufacturers.

CSAW staff carried out market assessment through questionnaire and telephone interview of architects and designers, focusing on the visual appeal of provided samples for appearance applications such as joinery and linings. Veneer was “graded” or categorised into three colour groups as shown in Figure 4. Veneer samples were then packaged and distributed as shown in Figure 5. Twenty-one people/companies were sent the information and seven responses were collected. The questionnaire and responses attached in Appendix 2.

QDAF staff used a standard questionnaire to interview 10 members of the timber production industry from six enterprises in person. The report on these interviews is attached in Appendix 3.



Light tone

Mid tone

Dark tone

**Figure 4: Coconut veneer tones established for the CSAW survey.**



**Figure 5: Coconut veneer samples as distributed.**

# Appendix 2: UTAS questionnaire and results



# Appendix 3: QDAF Market assessment and product performance requirements