Forest & Wood Products Australia

Roundwood & veneer processing investigations Technical Report

# INDIGENOUS COMMERCIAL FORESTRY OPPORTUNITIES:

## East Arnhem, northern Australia

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WARNING -
Aboriginal and Torres Strait Islander readers are advised that the following materials may contain the names, images and voices of deceased persons.

# Indigenous Commercial Forestry Opportunities – East Arnhem

## Roundwood and veneer processing investigations

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Queensland Government

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*The Department of Agriculture and Fisheries proudly acknowledges all First Nations peoples (Aboriginal peoples and Torres Strait Islanders) and the Traditional Owners and Custodians of the country on which we live and work. We acknowledge their continuing connection to land, waters and culture and commit to ongoing reconciliation. We pay our respect to their Elders past, present and emerging.*

# Contents

# 1. Introduction

Indigenous people have lived in and managed the Australian environment for well over 50,000 years and have played an integral role of shaping the forests in terms of biodiversity, ecosystem services and biophysical characteristics. The forests of northern Australia remain largely intact and are a result of the Indigenous peoples' long-term management.

Northern Australia has a history of Indigenous forestry activity, predominately small-scale sawmills and timber workshops established by missionaries to build housing and other basic infrastructure in many of the Indigenous communities in the region. The Indigenous forest industry remains small and fragmented, but there is potential for growth.

There are vast areas of Indigenous-owned forests throughout the East Arnhem region that have the potential to support a sustainable forest industry for the benefit of the local Aboriginal Traditional Owners and communities. It is well known that these forests contain native hardwood species with attractive wood properties – high strength, hardness, natural durability and other features – that make them suited to many value-added applications. However, there are a range of barriers preventing the benefits of Indigenous forestry operations from being realised in many areas of northern Australia including East Arnhem. This includes a lack of data on the productivity of these native forests, limited reliable mapping to support predictions of potential harvestable volumes and their locations, and wood product utilisation options. This report focuses on a preliminary investigation into select wood processing and product options.

While there is a small history of commercial timber processing in northern Australia which was reliant on using the native forest species such as Darwin stringybark (*Eucalyptus tetrodonta*), these efforts have been predominately focused on the supply of electricity network poles, bridge timbers (*e.g.* girders) and sawn timber (*e.g*. general construction materials). While these product options could be considered high-value products, these all require reasonably large diameter and high quality logs to maximise efficiency and profitability. Early indications from forest inventory studies and local observations suggest that there is a significant volume of resource in the northern Australian forests which contain log qualities that are not ideally suited for products such as poles, girders and high quality sawlogs, therefore there are obvious benefits in investigating alternative processing systems and products that better align to the available resource. In particular, it is expected that there are significant quantities of logs available within these forest areas which contain diameters that are too small for many current girder and pole markets, and too small for efficient sawmilling for construction sawn timber. Efficient processing systems for small diameter hardwood logs is a challenge not only for potential Indigenous forest operations in East Arnhem region, but exists for the broader Australian hardwood industry for both native managed forests and plantation resources.

Two particular processes identified for further investigations for the East Arnhem region and other northern Australian areas, targets processed roundwood products (*i.e.* post and bollard type products) and the second targets rotary veneer for veneer-based engineered wood product manufacture.

While there is limited market information available to support informed decisions on potential demand, scale and profitability, it is estimated that local demand for roundwood products such as bollards to demarcate boundaries for recreational parks, carparking, camping areas may be sufficient to support viable local production of these products. In addition, a relatively new method of bollard production has been identified that if found suitable, may provide a relatively low capital cost solution that requires minimal supporting infrastructure and minimal skills training to operate and maintain.

Rotary veneer processing using relatively new spindleless peeling technology has been shown in many recent research programs to be a very efficient method to process small-diameter hardwood logs yielding attractive volume and grade recoveries of veneer suitable for high-value veneer-based engineered wood products such as plywood and laminated veneer lumber. Compared to roundwood processing, this processing approach requires much larger capital investment, requires more comprehensive supporting infrastructure and demands a higher level of operator skills. However, opportunities for value-adding are much greater.

This study aimed to provide a preliminary technical investigation into both roundwood processing (targeting bollard production) and rotary veneer processing using small-diameter Darwin stringybark logs sourced from the East Arnhem region.

# 2. Experimental

## 2.1. Log Resource

Suitable Darwin stringybark (*Eucalyptus tetrodonta*) logs were selected from a native forest area in the East Arnhem region. After harvesting, these logs were docked to approximately 2200 mm in length and transported to the Queensland Department of Agriculture and Fisheries (DAF), Salisbury Research Facility in Brisbane, Queensland. This log length was selected to ensure that sufficient sections could be removed from each end to eliminate any end-splitting or other degrade that might occur between the time of harvest and processing, leaving a sufficient length for the target processing method.

Upon delivery, the centre diameter over bark (CDOB) of each log was measured and used to allocate logs to a processing method (either roundwood or rotary veneer). The allocation of logs to processing method was made by order ranking each log by centre diameter and then allocating the largest 36 logs to rotary veneer processing and the remaining 72 logs to roundwood processing.

After allocation, each log was then merchandised to remove approximately 435 mm from each end which was discarded, then a 25 mm disc from the small end of the logs were obtained for heartwood proportion determination. The remaining log length (approximately 1300 mm) had the following parameters measured before being processed in accordance with the assigned processing method allocation:

- Large-end diameter under bark or $LEDUB$ (m) – measured from the circumference with a diameter tape;
- Small-end diameter under bark or $SEDUB$ (m) – measured from the circumference with a diameter tape;
- Log length or $L$ (m) – measured using a length tape;
- Log sweep deviation or $a$ (mm) – measured as the maximum distance on the curved side of a log when a line is extended between the log ends and specifically used to calculate log sweep;
- Shortest small-end diameter or $SD$ (m) – the shortest small-end diameter measured using a steel ruler;
- Longest small-end diameter or $LD$ (m) – the longest small-end diameter measured using a steel ruler.

From the measured data, individual green log volume, V ($m^3$); log sweep, S (mm/m); log ovality, O (%); and log taper, T (mm/m) were determined using the following equations,

$$V = \left(\frac{SEDUB + LEDUB}{2}\right)^2 \times \pi \times L$$

$$S = \frac{a}{L}$$

$$O = \frac{LD - SD}{LD} \times 100$$

$$T = \frac{LEDUB - SEDUB}{L}$$

where $\pi$ is the mathematical constant number *pi* and all other variables are previously defined.

The discs removed during the log merchandising were used to measure heartwood proportion. Each disc had a heartwood indicator spray applied to allow the clear boundary between heartwood and sapwood to be determined. The disc radius (pith to disc periphery) along with the heartwood only radial distance were measured at four locations on each disc, allowing the proportion of heartwood to be calculated (Image 1).

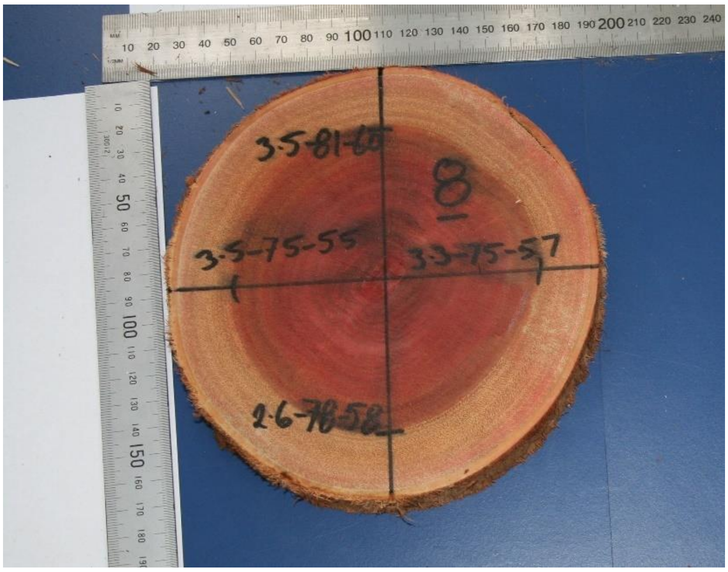


Image 1. Discs prepared for heartwood proportion and sapwood width measurements

## 2.2. Processing

### 2.2.1. Roundwood Processing

Following the merchandising process, the 72 billets allocated to roundwood processing were further allocated to six (6) different treatment groups (Table 1). The allocation of the billets was determined by the order ranking of the small-end diameter of each billet and then systematically allocating each billet to a treatment method (e.g. smallest log to Group 1, next smallest log to Group 2 etc.) such that there were 12 billets per treatment (Table 1). This resulted in batches of billets assigned to each treatment method with similar characteristics. Billets were then debarked and rounded in a dedicated rounding lathe targeting the removal of the non-durable sapwood, log ovality, log sweep and log taper; leaving a cylindrical bollard or post type roundwood product containing only the naturally durable heartwood.

Table 1. Billet allocation to treatment groups

| | Drying Method 1 | | | Drying Method 2 | | |
|---|---|---|---|---|---|---|
| | Surface Coating 1 | Surface Coating 2 | Surface Coating 3 | Surface Coating 1 | Surface Coating 2 | Surface Coating 3 |
| No. of bollards | 12 | 12 | 12 | 12 | 12 | 12 |

The six different treatment methods comprised of a combination of two drying methods and three surface coating systems (*i.e.* 2 drying methods x 3 surface coatings = 6 treatments). The two drying methods included, 1) an indoor, weather protected ambient South-east Queensland (SE Qld) air-drying condition, and 2) accelerated drying in a solar kiln. The solar kiln drying conditions were selected to simulate similar conditions (temperature and humidity) to what the roundwood products might be exposed to if air-dried in the northern Australia region, while the more gentle drying conditions of air-drying in SE Qld, represented more conservative conditions aimed at minimising possible drying degrade (*e.g.* splitting). Thirty-six roundwood products were assigned to each drying method.

Three surface coating systems were included targeting a reduction in drying induced degrade by slowing the roundwood product drying rate. The surface coating treatments included 1) a control (no coatings), 2) emulsified wax end-sealant applied on the roundwood ends only, and 3) emulsified wax end-sealer applied on the roundwood ends and the longitudinal surfaces coated with a penetrative oil.

Following their surface coating application, the roundwood products were exposed to their respective drying conditions for 171 days, during which the following measurements were taken at regular intervals:

- Maximum end check width $EC$ (mm) – maximum end check width measured using a vernier calliper on both ends (small-end, $ES$ and large-end, LE) of each roundwood product;
- Largest end splits $ES_n$ (mm) – the individual width (W) of the three largest splits on each end (therefore 6 end splits in total per billet) were measured using a vernier calliper, the corresponding length (L) of each split was measured using a steel rule; and

- Surface checking $SC$ (mm) – visual assessment to determine approximate percentage of roundwood product subject to surface checking, while the maximum surface check width was measured using a vernier calliper.

From the measured end split data end of both the small end (SE) and large end (LE) of the billet, mean end split area, $A_{ES}$ (mm$^2$) for each billet was determined using the following equation:

$$A_{ES} = \frac{\sum_{SE}\left(W_{ES_i} \times L_{ES_i}\right) + \sum_{LE}\left(W_{ES_i} \times L_{ES_i}\right)}{6}$$

The temperature ($T$) and relative humidity ($h$) experienced during the drying term for each drying method were recorded using a HOBO© U-Series Data Logger. This data was used to calculate the equilibrium moisture content percentage ($EMC$) that the roundwood products were exposed to during the drying period. The EMC was determined by the following equation:

$$EMC = \frac{1800}{W} + \frac{(K_1Kh + 2K_1K_2K^2h^2)}{(1 + K_1Kh + K_1K_2K^2h^2)}$$

$$W = 330 + 0.452T + 0.00415T^2$$

$$K = 0.791 + 0.000463T + 0.000000844T^2$$

$$K_1 = 6.34 + 0.000775T + 0.0000935T^2$$

$$K_2 = 1.09 + 0.0284T + 0.0000904T^2$$

Where $T$ is converted to degrees Fahrenheit, $h$ is expressed in decimal form and all other variables are previously defined.

### 2.2.2. Rotary Veneer Processing

The billets allocated to rotary veneer processing were pre-heated using saturated steam until the billet cores reached approximately 55ºC. Immediately after being pre-heated, logs were debarked, and rounded in a dedicated rounding lathe before being peeled into rotary veneer. Veneer processing was undertaken using a semi-industrial scale spindleless veneer lathe. The lathe is capable of processing billets up to 1300 mm in length and 500 mm in diameter. The minimum peeler core size is ~44 mm. For this study, nominal dried veneer thickness was selected as 3.0 mm.

The resulting veneer ribbon was subsequently clipped targeting a maximum sheet width of 1300mm (targeting a final dried and trimmed veneer sheet width of 1200 mm). Sheets with widths below 1300 mm, but above 300 mm were also recovered. Clipped veneer sheets were labelled with a unique identifier and dried in a solar kiln to approximately 10% moisture content. The following parameters were measured on the veneer sheets:

- Dried veneer thickness (DT) — the mean thickness of each dried veneer sheet was calculated from measurements recorded at two positions along the veneer sheet using a dial thickness gauge; and
- Dried veneer width (DW) — the width (perpendicular to the grain) of each dried veneer sheet.

#### 2.2.2.1. Veneer Assessment

The veneer quality was assessed in accordance with Australia and New Zealand Standard AS/NZS 2269.0:2012 (2012). This standard follows principles reflected in other international visual grading classification systems. Structural veneers are categorised into four different surface quality grades and a reject grade based on the severity and concentration of imperfections and defects.

To facilitate veneer comparison, the lathe settings remained consistent across all billets. The visual grade for each type of defect present was recorded for each veneer. This allowed the analysis of the impact of each defect type in relation to its contribution to the assigned grade. The defect causing the lowest visual grade was identified as the grade limiting defect(s) and the resulting assigned grade was recorded for each veneer.

#### 2.2.2.2. Recovery Analysis

Four recovery calculation methods were used: dry veneer recovery (DR), gross veneer recovery (GSR), net veneer recovery (NR), and graded veneer recovery.

The DR provides a useful measure of the maximum recovery and takes into account the log geometry (sweep, taper, and circularity), lathe limitations (*e.g.* peeler core size), and drying process (*e.g.* veneer shrinkage, *etc.*). The DR disregards internal log quality and was calculated in percentage as follows:

$$DR = \left(\frac{L \times \sum_{veneer}(DT \times DW)}{\sum_{billet} V}\right) \times 100$$

where DT is the average dry veneer thickness of each veneer (m), and DW is the dry veneer width (m, perpendicular to the grain).

The GSR provides a useful measure of the maximum recovery of dried veneer that meets the quality specifications of AS/NZS 2269.0:2012 (2012) (A-grade to D-grade). This recovery includes the losses accounted for in dry veneer recovery, but also includes additional losses from visual grading (i.e., veneers that failed to meet grade). The gross veneer recovery (GSR, %) was calculated as follows:

$$GSR = \frac{L \times \sum_{veneer}(DT \times GRW)}{\sum_{billet} V} \times 100$$

where GRW is the width (m, perpendicular to the grain) of the dried veneer that meets the A-, B-, C-, and D-grade requirements, in accordance with AS/NZS 2269.0:2012 (2012).

The NR enables analysis of the efficiency of the process, as it determines the proportion of saleable product recovered, and takes into consideration any limiting factors of the product manufacturing process. The NR includes the losses measured in the GSR, along with the further losses that result from trimming of the veneer within product manufacturing stages. The losses resulting from veneer sheets being reduced in width to the final product dimension is called the trimming factor. In this study, the trimming factor corresponded to reducing the veneer sheet width perpendicular to the grain from 1275 mm to 1200 mm and the veneer sheet length (parallel to the grain) from 1300 mm to 1200 mm. The NR (%) was calculated as follows:

$$NR = GSR \times \frac{1200}{1275} \times \frac{1200}{1300}$$

Thus,

$$NR = GSR \times 0.869$$

The graded veneer recovery separates the net veneer recovery into each grade quality classification in accordance with AS/NZS 2269.0:2012 (2012) (i.e., A-, B-, C-, or D-grade). Each grade quality classification was individually calculated and labelled NRA, NRB, NRC, and NRD.

# 3. Results and Discussion

## 3.1. Log Resource

108 logs were supplied for processing and the largest 36 logs, which ranged from 275 mm to 358 mm CDOB, were allocated to the veneer processing (see Table 2, Image 2). After merchandising to the final billet length, 3.01 $m^3$ of log volume was available for rotary veneer processing. The remaining 72 logs, which ranged from 168 mm to 272 mm CDOB, were allocated to roundwood processing (see Table 2). After merchandising to the final billet length, 3.36 $m^3$ of log volume was available for roundwood processing.

Table 2. Log and assigned billet summary

| | Un-merchandised Logs (n=108) | Roundwood Billets (n=72) | | Veneer Billets (n=36) | |
|---|---|---|---|---|---|
| | Centre Diameter Over Bark (mm) | Large-end Diameter Under Bark (mm) | Small-end Diameter Under Bark (mm) | Large-end Diameter Under Bark (mm) | Small-end Diameter Under Bark (mm) |
| Mean | 249 | 215 | 202 | 293 | 277 |
| Minimum | 168 | 158 | 150 | 253 | 238 |
| Maximum | 358 | 273 | 253 | 385 | 325 |

Image 2. Darwin stringbark logs being allocated to processing method

The variation in log sweep and log taper, and log small-end ovality are illustrated in Figure 1 and Figure 2 respectively. Log taper, sweep and ovality can negatively affect the potential volume recovered during roundwood and veneer processing of logs as the rounding process needs to remove these characteristics leaving a cylindrical column. The mean sweep, taper and ovality was 10.3 mm/m, 10.2 mm/m and 7.3% respectively. The results highlight the relatively low sweep, taper and ovality that existed in the supplied logs, and the levels were within the expected range of similar hardwood species (*e.g. Eucalyptus* and *Corymbia* spp.) (McGavin *et al.* 2014). By comparison, mid to near-end rotation plantation African mahogany logs grown in northern Australia have been shown to exhibit larger levels of sweep (mean values between around 10-15 mm/m), much higher levels of taper (mean values between 31-37 mm/m) and similar ovality values (mean values around 5-7%) (McGavin *et al.* 2021).

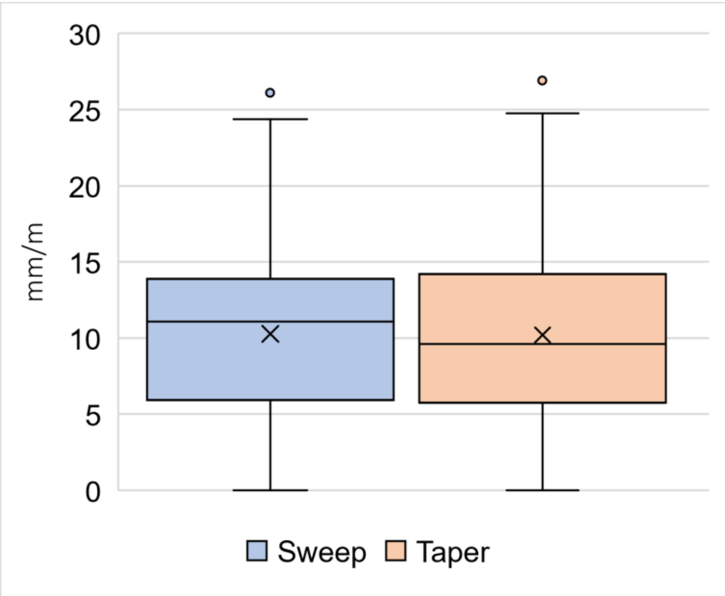


Figure 1. Log sweep and log taper (n=108)

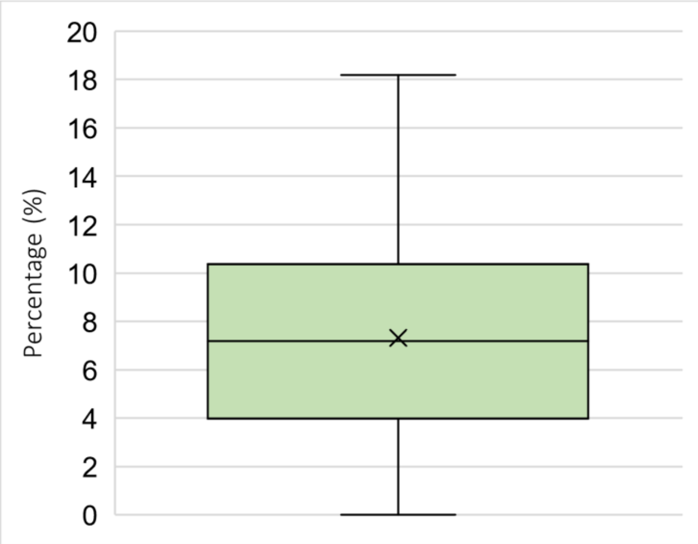


Figure 2. Log ovality (n=108)

In addition to the log geometric characteristics, the heartwood proportion present in the logs was measured. The heartwood proportion is probably more relevant to the roundwood processing of this study as the objective was to remove all of the sapwood during processing leaving only the naturally durable heartwood, therefore a higher heartwood proportion is more desirable. The heartwood proportion results are presented in Figure 3 for the billets of each processing method.

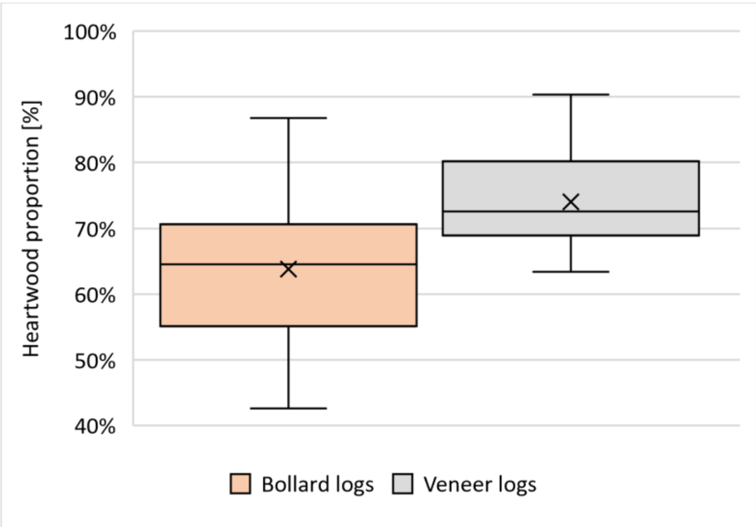


Figure 3. Log heartwood proportion for each processing method.

The logs allocated to roundwood processing generally had a lower heartwood proportion and therefore more non-durable sapwood than the logs allocated to veneer processing, with an average percentage of 64% and 74% respectively. This is likely attributed to the log diameter differences with the smaller logs often expected to have a lower heartwood proportion, perhaps also indicative of the smaller diameter trees being younger.

## 3.2. Roundwood Processing

### 3.2.1. Product Recovery

The 72 billets allocated to roundwood processing were debarked and rounded in a dedicated rounding lathe (Image 3 and 4). This processing machine is the same equipment used to prepare billets for spindleless rotary veneer processing. Table 3 presents the summary pre- and post-processing billet details. A billet volume of 3.36 $m^3$ was included in the roundwood processing study, which yielded 1.47 $m^3$ of roundwood product, providing a product recovery of 44%.

Image 3. Spindleless debarker and rounding lathe used to prepare the roundwood products

Table 3. Roundwood product recovery

| | | | |
|---|---|---|---|
| Pre-processing | Mean diameter (mm) | 221 | *(29.4)* |
| | Mean billet volume ($m^3$) | 0.053 | *(0.014)* |
| | Total volume ($m^3$) | 3.36 | |
| Post-processing | Mean diameter (mm) | 140 | *(25.9)* |
| | Mean bollard volume ($m^3$) | 0.020 | *(0.008)* |
| | Total volume ($m^3$) | 1.47 | |
| Roundwood product recovery (%) | | 44% | |

Note: standard deviations included in parenthesis.

Image 4. Roundwood products post processing

The product recovery is low compared to rotary veneer processing (see Section 3.3), however is higher than what would be expected from sawing logs of these dimensions into sawn timber. McGavin and Leggate (2019) reported sawn timber recovery rates for final products of around 14–20% for different species of Australian hardwood logs but of similar log similar dimensions.

The roundwood product recovery rate was directly influenced by the adopted processing method which targeted roundwood products that excluded any sapwood (due to it's low natural durability). Removing the naturally non-durable sapwood, leaving only the naturally durable heartwood enables roundwood products to be produced (*e.g.* bollards, posts) that could be used in weather exposed applications without the need to undertake preservative chemical treatment. Naturally durable products may provide some market access advantages over preservative chemically treated products. The product recovery rate could be improved by removing the log ovaility, sweep and taper, but retaining some sapwood, however this would then require the products to be preservative chemical treated if the products were to be used in weather exposed applications.

Following processing, the roundwood products were allocated to six different treatments (see Section 2.2.1) and allowed to dry (or season).

### 3.2.2. Product Drying

Two different drying environments were included in the study: 1) an indoor, weather protected ambient South-east Queensland (SE Qld) air-drying condition, and 2) accelerated drying in a solar kiln. During the 171 days of drying, the daily average equilibrium moisture content (EMC) was determined for each drying environment (Figure 4). As expected, the EMC conditions in the solar kiln environment (mean EMC of 9.5% over the drying period) was systematically lower than the EMC conditions in the ambient air-drying conditions (mean EMC 11%), thus providing a drier environment therefore faster drying conditions. At the commencement of drying, the roundwood products had a moisture content of around 50%. After 171 days of drying, the air-dried roundwood products had a moisture content of around 24%, while the solar kiln products had a moisture content of around 14%, demonstrating the different drying rates of the two drying methods.

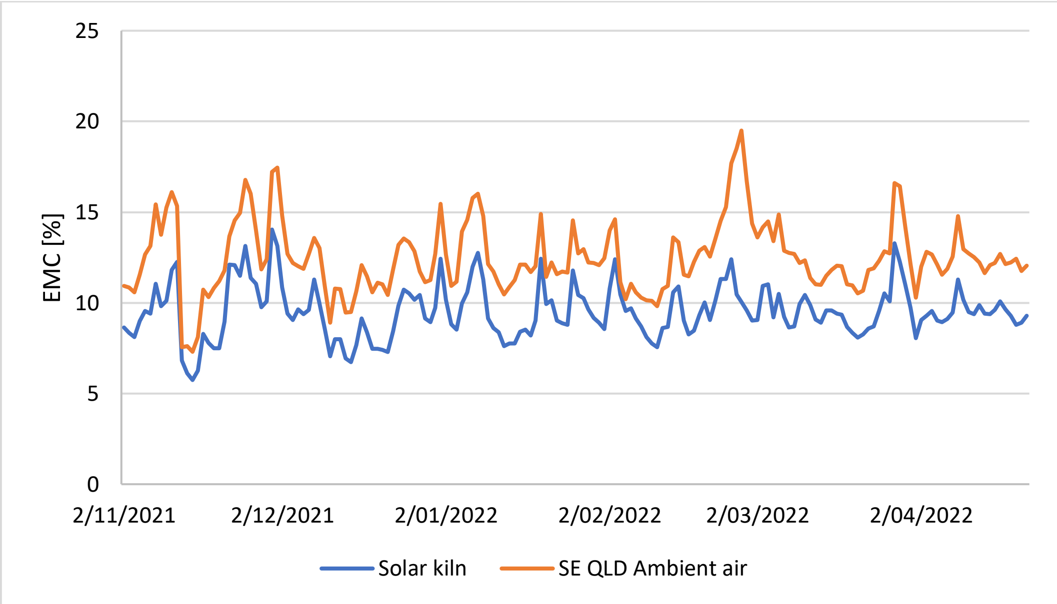


Figure 4. Daily average EMC for the two drying environments.

Figure , 6 and 7 illustrate the development of drying degrades $A_{ES}$, $EC$, and $SC$ respectively, over the 171 days of monitoring allowing comparison of the drying environments. Overall, the drying degrade was slightly more severe for the solar kiln dried roundwood products compared to the air-dried products, which is in-line with the difference in EMC conditions and resultant drying rate of the two methods. The roundwood products dried in ambient air-drying conditions experienced some splitting and checking particularly in the first two weeks. However, as time progressed, the degree of drying degrade stabilised. A minor reduction in split and check size was observed during the later stages of drying, likely attributed to the reduced moisture content gradient within the products.

The roundwood products subjected to solar kiln drying dried at a faster rate which resulted in larger and higher frequency of checks and splits. Most of the checks and splits had fully developed in the first 30 days following processing. Similar to the air-dried roundwood products, the solar kiln dried roundwood products experienced a reduction in checks and splits during the later stages. While the degrade levels were more severe compared to air-drying, the magnitude of difference was relatively low, with most checks and splits probably being within acceptable limits in most potential markets. This suggests that following some basic protocols, that air-drying Darwin stringybark roundwood products in climates like East Arnhem (which would be expected to be similar to the south-east Queensland solar kiln drying conditions in this trial) should provide market acceptable quality.

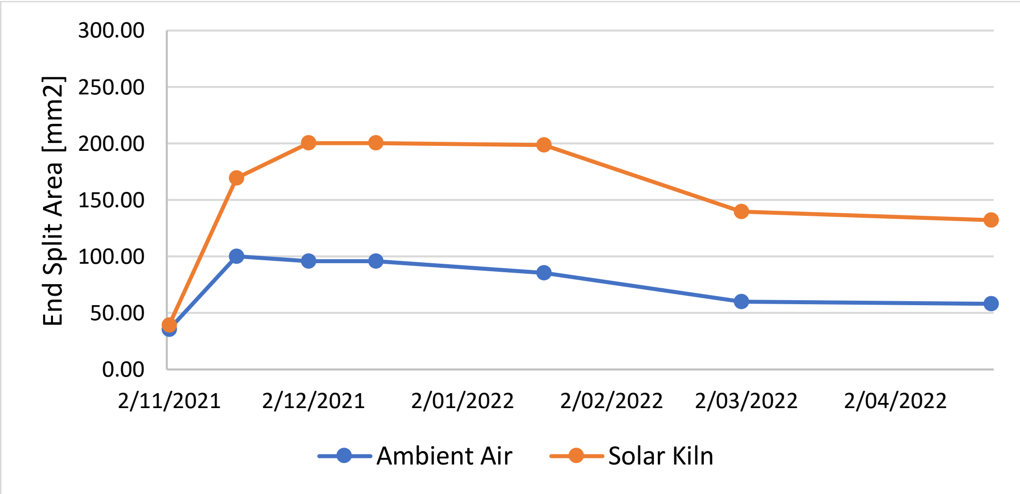


Figure 5. Roundwood average end split area ($A_{ES}$) area for the two drying methods.

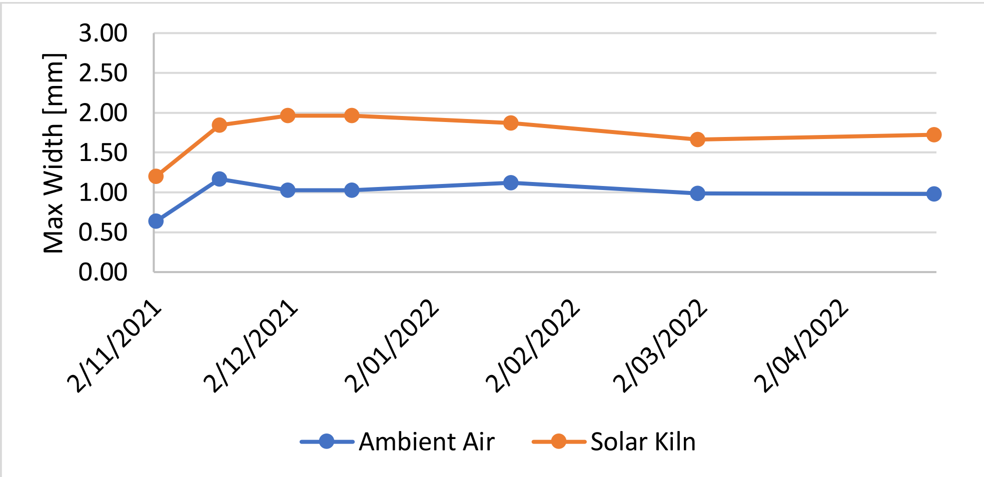


Figure 6. Roundwood mean end-check maximum width for the two drying methods.

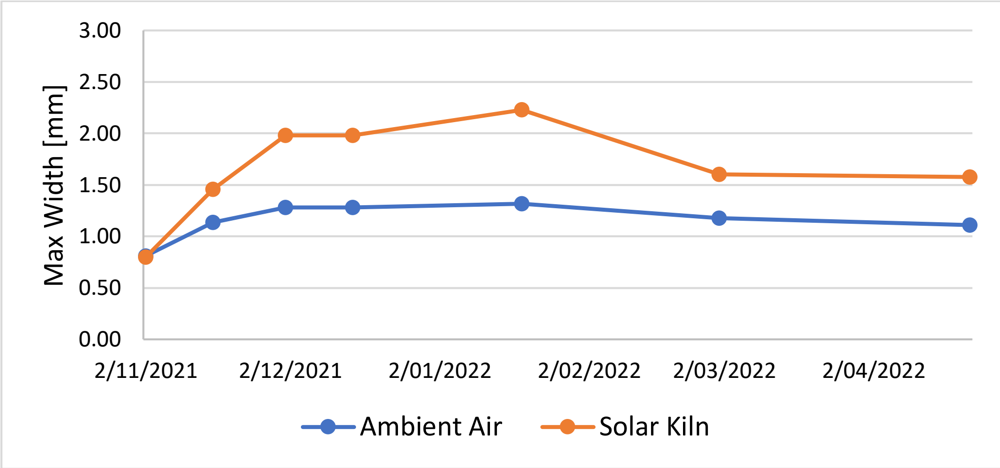


Figure 7. Roundwood mean surface check maximum width for the two drying methods.

In addition, the occurrence of shelling in some of the roundwood products was observed independent of the drying methods. Shelling is the separation of wood fibre in the radial direction (parallel to the growth rings) and isn't normally troublesome in sub-tropical and tropical hardwood resources in Australia, however, shelling was observed in 15 roundwood products (ambient air drying = 8 products and solar kiln drying = 7 products) (Image 5). Further investigations are necessary to determine the resource propensity to shelling and how representative the supplied logs were compared to the wider resource.

Image 5. Shelling present on some log ends

#### 3.2.3. Surface Coating Systems

In addition to drying method, the influence of three surface coating systems on the development of checks and splits was evaluated. The observed development of $A_{ES}$, $EC$, and $SC$ of each roundwood product was measured and illustrated in **Error! Reference source not found.**, 9 and 10 respectively. Of the 76 bollards, 24 had no surface coating, 24 bollards had emulsified wax end sealant, and the remaining 24 had emulsified wax end sealant and a timber oil as a surface coating.

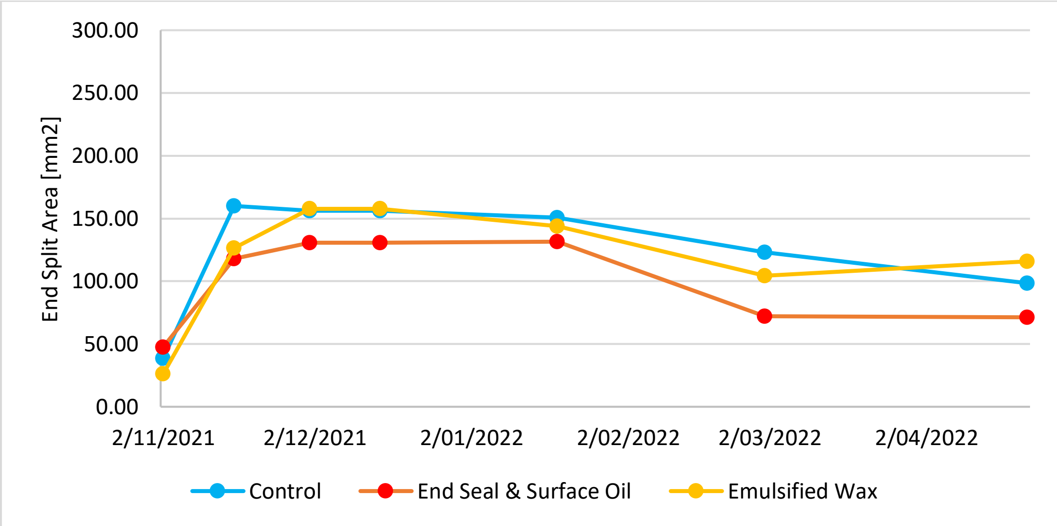


Figure 8. Roundwood product average end split area for the three coating systems.

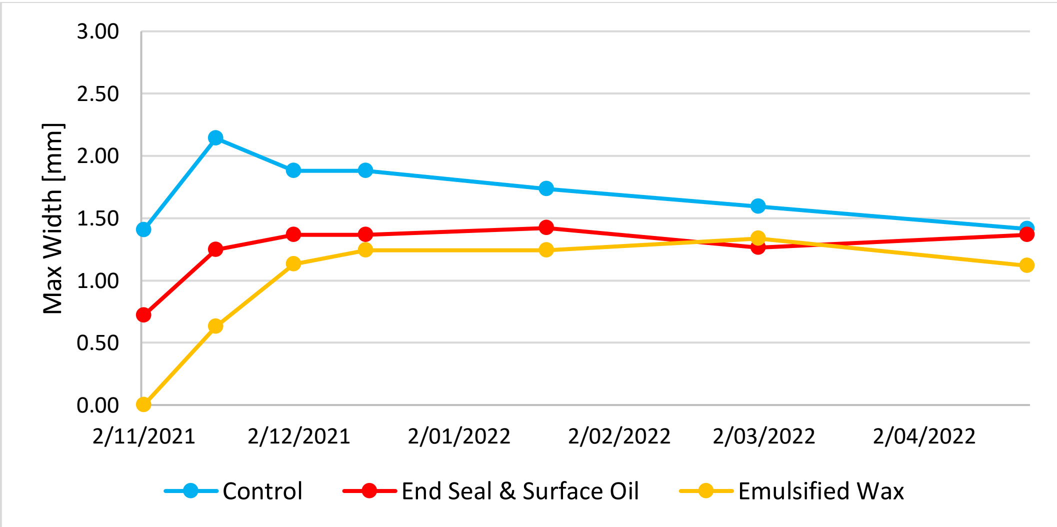


Figure 9. Roundwood product mean end check maximum width for the three coating systems

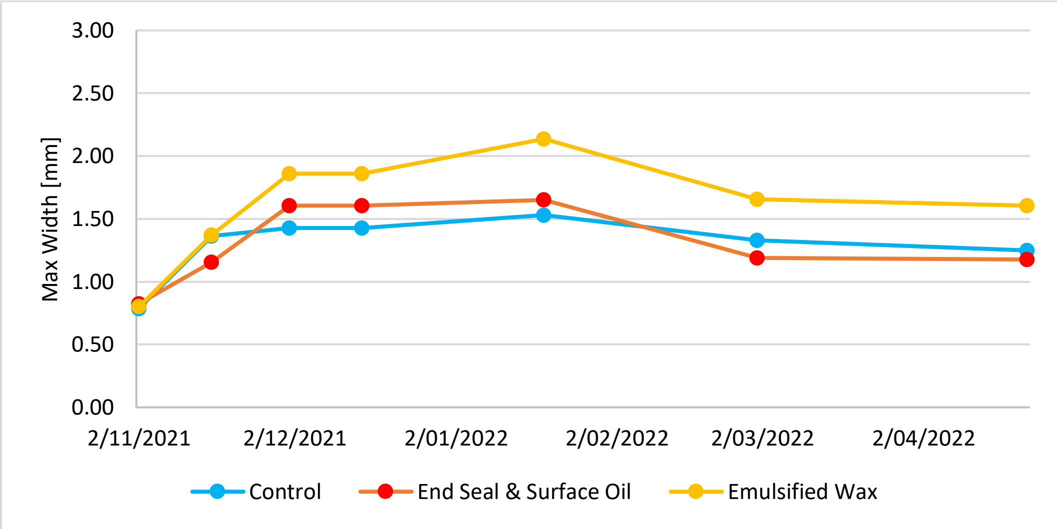


Figure 10. Roundwood product mean surface check maximum width for the three coating systems.

The control samples were expected to experience the worst splits and checking, the use of an end-sealer was expected to reduce the occurrence of end splitting and end-checking, and combining the end-sealer and penetrative oil applied to the product surface was expected to reduce the occurrence of end splitting, end checks and surface checking. In general, the roundwood products drying degrade results followed the expectations of the various treatments, however the different performances between treatments were minimal. A larger sample size may allow more accurate separation of the different treatments and the potential benefits of the end-sealer and penetrative oil to be better realised.

Interestingly, the influence of surface coating methods was noticeable when comparing the occurrences of shelling, as details below:

i. Control = 10 bollards with shelling,
ii. End Seal and Surface Oil = 2 bollards with shelling,
iii. Emulsified Wax = 3 bollards with shelling.

While the end-sealer and penetrative oil treatments aren't expected to be a solution for the potential shelling issue, reducing the drying rate and therefore narrowing the moisture gradient within the roundwood product has appeared to reduce the occurrence of the shelling splits. This should be investigated further once the resource is screened to understand the resource propensity to shelling and how representative the supplied logs were compared to the wider resource.

## 3.3. Veneer Processing

The veneer recovery analysis is displayed in Table 4 below. The mean dry veneer recovery was 55%. This recovery calculation does not include any visual grading, but does include the losses that occur during rounding, peeling, clipping and drying (i.e. process losses).

Table 4. Veneer recoveries

| | Dry Veneer Recovery (% of log volume) | Gross Veneer Recovery (% of log volume) | Gross Veneer Recovery (% of dry veneer volume) | Net Veneer Recovery (% of log volume) |
|---|---|---|---|---|
| Mean | 55 | 39 | 70 | 34 |

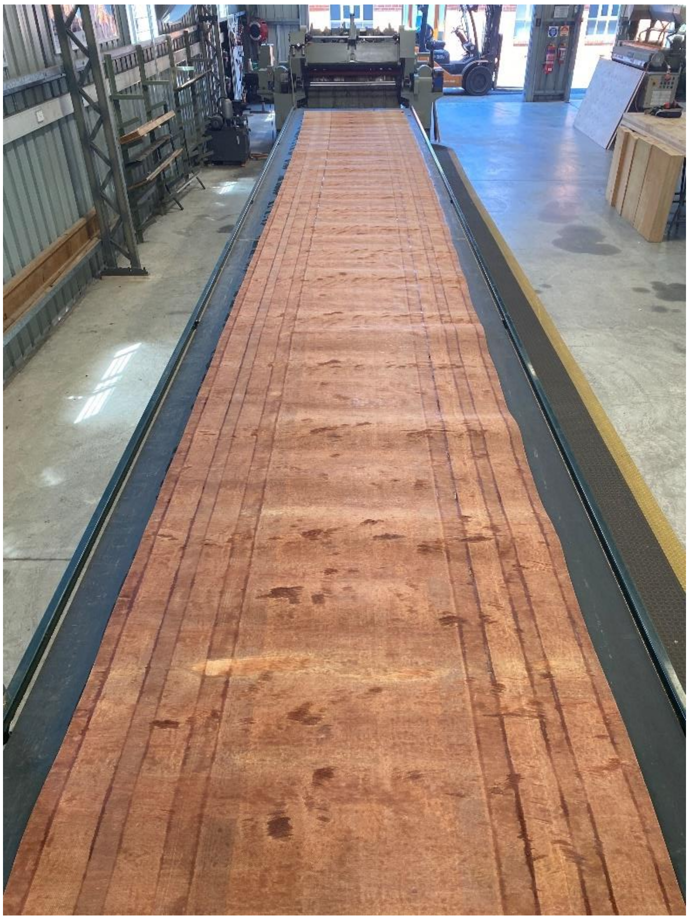

Image 6. Veneer ribbon resulting from rotary veneer processing

While this is high compared to sawmilling, it is lower than usually achieved in other spindleless veneer processing studies which have processed logs of similar sizes. Usually the variability in recovery is explained by the log geometry (diameter, ovality, sweep and taper), where high rates of deviation from a cylindrical column typically result in lower recovery rates, however in this study, it is the size of the peeler core (the residual core that remains after peeling) that had most influence. The spindleless lathe used in the study is capable of producing peeler cores with diameters of around 4 cm, however, the average peeler core size achieved in the trial was 11 cm, with the largest peeler core being 45 cm. This was due to a high occurrence of internal log defects, particularly close to the log centre, and included pipe, termite galleries, decay and shelling, which prevented the billets from peeling to the target peeler core size (Image 7). These defects significantly impacted the dry veneer recovery result.

Image 7. Oversized peeler cores that resulted from internal log defects.

Gross veneer recovery is a measure of the proportion of either dry veneer or log volume that meets the quality specifications of AS/NZS 2269.0:2012 (2012) (A-grade to D-grade). The gross veneer recovery achieved in this study was 39% (proportion of log volume) and 70% (proportion of dry veneer volume) which are also lower than usually experienced with this processing method.  The net veneer recovery which indicates the recovery of saleable veneer in the finished dimension (trimmed to correct size) was 34% (of log volume). This is about 25% lower than that reported by McGavin et al. (2021, 2019, 2014) in various other studies.

Recovered veneer sheets were graded to the quality specifications of AS/NZS 2269.0:2012 (2012) and all of the net veneer volume achieved a visual grade of D-grade. Despite D-grade being the lowest visual grade quality for structural veneers, they would be suitable for face veneers in non-appearance structural panels and can be used as core veneers in the manufacture of many different appearance and non-appearance structural panels.

The top 5 ranked defects that prevented veneer sheets from achieving a grade higher than D-grade are listed in Table 1. Note that some veneers may be grade limited due to more than one defect. Veneer roughness and grain breakout prevent almost all veneers from achieving a grade higher than D-grade. The occurrence of these defects, which are potentially related, are probably present due to a combination of wood quality (e.g. wavy or curly grain) and processing influences. Modifications to the processing protocols, such as target log temperature, lathe setup etc, may lead to an improvement in recovery high grade qualities.

Table 1. Top 5 ranked defects preventing graded veneers from attaining assigned grades higher than D-Grade

| Rank | Defect | % Veneers subject to defect |
|---|---|---|
| 1 | Roughness | 99% |
| 2 | Grain Breakout | 93% |
| 3 | Cumulative Defects | 74% |
| 4 | Splits | 29% |
| 5 | Fractured Unsound Knots | 26% |

# 4. Conclusion

1. This study provided a preliminary technical investigation into both roundwood processing (targeting bollard production) and rotary veneer processing using small-diameter Darwin stringybark logs sourced from the East Arnhem region.

2. 108 Darwin stringybark logs were provided to the study. The largest 36 logs (mean small-end diameter of 277 mm) were processed into rotary veneer using a spindleless rotary veneer lathe. The remaining 72 logs (mean small-end diameter of 202 mm) were processed into sapwood-free roundwood products.

   The roundwood processing recovered 44% of the input log volume into product. Drying trials indicated that the roundwood products dried without severe splitting and checking, either by air-drying or accelerated solar kiln drying. Applying end-sealer or end-sealer in combination with a penetrative oil coating showed some benefits.

3. The veneer processing recovered 34% of the input log volume into rotary veneer that met that meets the quality specifications of AS/NZS 2269.0:2012. All veneers meet the requirements of D-grade. Despite D-grade being the lowest visual grade quality for structural veneers, they would be suitable for face veneers in non-appearance structural panels and can be used as core veneers in the manufacture of many different appearance and non-appearance structural panels. Veneer roughness and grain breakout preventing almost all veneers from achieving a grade quality higher than D-grade. Modifications to the processing protocols, such as target log temperature, lathe setup etc, may lead to an improvement in recovery high grade qualities.

4. While the study didn't extend to undertaking any financial analysis, skills analysis, market analysis *etc*, based on the results of the study, it is recommended to further investigate roundwood processing as a commercial processing option to use the smaller-diameter Darwin stringybark logs. The fixed capital investment for the core equipment would be approximately A$100,000, versus approximately A$4M for a full rotary veneer processing line. It would be suspected that sufficient local markets could be developed quickly to support early production of roundwood bollards (Image 8) *etc*, while broader markets could be explored.

Image 8. Darwin stringybark roundwood products (bollards) ready for installation.

# 5. References

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