APPLICATION OF THE HEWSAW R250 FOR SAWING EUCALYPT LOGS WITH A RANGE OF LONGITUDINAL PERIPHERAL GROWTH STRESS LEVELS.

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SUMMARY
The effectiveness of eucalypt sawmilling lies with the ability of the sawing equipment to control the release of growth stresses in an efficient manner during log break-down. Where there is poor control, which can be the case with conventional hardwood systems, board deflection, sawing accuracy, splitting ahead of the saws and board end splitting can result in low product quality and/or recovery. With these inefficiencies, coupled with slow material throughput, it is probable that conventional eucalypt sawing systems will have to make way for more appropriate sawing technology if plantation-grown eucalypts are to be a viable resource for production of sawn timber.

Possible processing options that have emerged in recent years are the HewSaw single pass machines and sawing lines. These machines apply chippers and small diameter circular saws in such a way that growth stress release may be controlled. One of these machines, the HewSaw R250 owned by NF McDonnell & Sons (now Carter Holt Harvey), was applied in sawing trials with 17-year-old *E. nitens* logs. 117 logs (5.0 m long) were obtained from four seedlots in two Forest NSW trials. Growth stress levels were assessed to measure board behavioural characteristics associated with growth stress release.

The trial results indicated that spring was very minor, and the extension of existing log end splitting and splitting ahead of the saws was not observed. Board deflection in the form of bow was the main characteristic attributed to growth stress release. However, while modifications to conveyors and board sorters would improve material flow, bow was insufficient to cause major problems in the mill.

In addition, as a consequence of increased log length there were indications that recovery losses due to board end-splitting can be reduced with these systems in comparison to more conventional hardwood mills processing shorter logs. This was because end split length was less as a proportion of log length.

Additional sawing and drying trials are planned with a range of eucalypts to further assess the capacity of this technology to process logs with high growth stresses. These trials will include a financial comparison with conventional hardwood sawmills and experiment with quarter-sawing for collapse prone eucalypts.

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INTRODUCTION

Conventional hardwood sawmills in Australia are reasonably well set up to cope with the log quality and size from native forests which make up their normal log supply. These logs are generally large and variable in diameter and sawing strategies have been developed to cope with the inherent log quality in the production of high quality appearance and structural grade timber. These systems usually employ reciprocating carriages with single and twin saws for log break-down coupled with single or multi-saw resaws to produce final dimensioned boards or slabs for drying.

It is clear that conventional systems are less well suited to small diameter plantation-grown eucalypts than older and larger diameter logs from native forests. Washusen and Innes (2007) reviewed the basic types of systems operating in Australia with reference to their capability to process plantation-grown eucalypts from trials conducted across Australia in recent years. The reader is directed to this for further detail. The main issues identified by Washusen and Innes as limiting sawmilling efficiency and potentially limiting product value as a consequence of the sawing process in conventional hardwood mills are:

- Sawing accuracy in single-saw systems,
- Large saw kerf, particularly in large diameter circular saws,
- Log-end and cant end-splitting,
- Splitting ahead of the saw,
- The requirement to rotate logs during sawing, and
- The reciprocation of logs through breakdown saws, and in the more conventional systems the reciprocation of flitches and slabs through resaws.
- In addition board deflection in the form of spring and bow can be value limiting.

These limitations are all at least partly the consequence of the release of longitudinal peripheral growth stresses that are generated in trees and remain in the logs until they are released or partially released during sawing.

In large diameter native forest logs these limitations are of little consequence and logs are commonly sawn at lengths exceeding 4.8 m. However, in small diameter plantation-grown eucalypts (SED 20-35 cm) log length is often reduced to 2.7 – 3.0 m in order to control growth stress release. In reciprocating systems this has serious impacts on sawmill efficiency, and even under these circumstances, with the best available sawing technology, problems can and do arise (Figure 1).

![Figure 1. Log end-splitting in 17-year-old E. saligna, the consequence of sawing to produce a cant that is too thin relative to the log diameter.](image)
One way to alleviate this problem is to apply symmetrical sawing patterns and maintain a linear flow. The HewSaw single pass machines and sawing lines are an example of this type of system. They also employ an added feature of profiling the cant and boards with chippers.

A diagrammatic representation of the cutting pattern for a HewSaw R250 single pass machine is illustrated in Figure 2. This shows that chippers are applied ahead of small circular saws and additional chippers applied behind the saws to complete the profile of boards above and below the centre boards. This cutting pattern has a number of important features:

- Firstly, the chippers remove the most highly stressed wood as wood chip from around the log in a symmetrical fashion. This is likely to reduce the potential for worsening of harvest related log end splitting (as was the case in Figure 1), splitting ahead of the saw and board deflection.

- The small diameter multi-saws produce accurately dimensioned boards in thickness. In comparison board thickness variation can be a problem with single saw systems.

- All boards are dimensioned in width at completion of sawing eliminating the potential for further board deflection on re-sawing.

This project was set up primarily to assess the potential of the HewSaw R250 to achieve these effects along with an assessment of board deflection and consequences for material flow from logs with a large range in growth stress severity.

![Figure 2: A diagrammatic representation of the internal mechanisms of the HewSaw R250 showing an example of the typical configuration of the saws and chippers (from HewSaw.com)](image)

**MATERIALS AND METHODS**

**The Plantation**

To obtain sufficient numbers of logs for the assessment trees were sourced from two Forests NSW trials located at the same site in the Bago State Forest near Tumut in southern New South Wales, Australia. The trees were 17-years-old at the time of the assessment, they had not been pruned and were unthinned. Four *E. nitens* seedlots, Toorongo Plateau, Powell Town, SSO VRD 36 and Barrington Tops, were selected to test for genetic differences in sawmilling performance. This assessment is reported in Washusen et al. (2007a). Trees were selected if they could potentially produce a single 5.0 m long log from the base of the stem with an estimated small end diameter (SED) of 24-30 cm (after estimating bark thickness and taper) and with allowable sweep and log shape for processing on the HewSaw. Trees with excessive sweep (equivalent to 25% of the log diameter over the log length), excessive branching and eccentricity at the butt end were avoided. In total 134 trees were selected that met this criteria.

*E. nitens* was selected for this trial because inventory records indicated that it was one of the best performing species in terms of growth and survival. In addition it has already been
demonstrated that logs up to 24 cm SED of this species has potential to be sawn on modern linear type sawing systems at the Forest Enterprises Australia mill at Bell Bay, Tasmania.

Growth strain measurement
Prior to harvest, growth strain was measured at the northwest and southeast locations at breast height with the CIRAD Foret method (Yang et al. 2005) (Figure 3). This instrument consists of an electronic gauge with mechanical sensors attached on a metal frame. After the removal of a bark window, approximately 200 x 100 mm, the frame is strapped around the tree. The nominal distance between two pins, which are punched into the wood surface, is 45 mm. A hole is drilled between the sensors and the frame (mid-distance between two pins), which releases the longitudinal stresses. The electronic gauge measured the change in distance between two pins (the growth strain).

The ‘growth strain’ was used as an estimate of the longitudinal growth stress.

![Figure 3: CIRAD-Foret growth stress gauge positioned on the stem of *E. nitens* before and after drilling](image)

Harvest
Harvesting and de-barking were conducted with a mechanical harvester about 2 weeks after the standing tree growth strain measurements were taken. Prior to harvest each tree selected was marked at the 0.3 m height above ground and from this a reference mark was placed on the stem above the height of the felling head. This allowed the harvester operator to accurately position the felling head so that the felling cut was consistently at the 0.3 m height. The bush logs were debarked and cross-cut to produce a single 5.0 m log at the butt end. The logs were loaded on a truck and transported to N. F. McDonnell & Sons in Yarram, Victoria, Australia.

Log preparation
At the mill some logs were rejected because of excessive sweep and small diameter giving a total of 117 logs for the trial. These represented the range in growth strain found in the plantations. Prior to sawing log dimensions (smallest and largest diameter at each end, log length and sweep) and end-split length on the log-end and extension along the log were recorded. Each log was painted with a unique log number on the large end of the log so that the log number could be recorded just prior to sawing.

Log volume was calculated from the mean diameter and the severity of log-end splits was calculated as Split Index 2 (SI-2) (Yang 2005)

Log sorting and sawing
After the logs were prepared they were handled using normal procedures at the mill (Figure 4). They were first scanned and segregated into the three diameter classes and sawn with the three sawing patterns according to log size shown in Figure 5. The minimum SED ranges were 22.0-26.0 cm, 24.0-28.0 cm and 26.0-32.0 cm, indicating a 2.0 cm overlap in minimum SED between adjacent groups.

Analysis of data after sawing indicated that the minimum SED as opposed to mean or maximum SED was the most important measurement in explaining board behaviour.
Figure 4: Log handling and sawing; Top; loading logs for scanning and sorting into diameter classes (left); logs sorted into diameter classes (right); Bottom; logs on the infeed deck to the sawmill with individual log numbers painted on the large end (left); the HewSaw R250 (right).

At the outfeed of the HewSaw R250 the leading ends of the boards from each log were photographed just before the boards were picked up by the conveyor. This gave an indication of the approximate range of board deflection for each sawing pattern. This approximate range is shown in Figure 6. The boards were segregated into sizes and stacked with automatic board stackers.

The overall range in deflection was not great enough to cause major problems for board transport on the conveyers and during stacking.

**Board measurement**

At completion of sawing the board dimensions, spring, bow and board end-split length at the small and large ends were recorded for each board and log.
Figure 5: Sawing pattern 1 applied for the 22.0-26.0 cm minimum SED (left), sawing pattern 2 for the 24.0-28.0 cm minimum SED (middle) and sawing pattern 3 for the 26.0-32.0 minimum cm SED (right) log diameter groups.
Figure 6: The approximate range in bow for the 3 sawing patterns; top and bottom left, the 22.0-26.0 cm minimum SED group (sawing pattern 1); top and bottom centre, the 24.0-28.0 cm minimum SED group (sawing pattern 2); and, top and bottom right the 26.0-32.0 cm minimum SED group (sawing pattern 3).
RESULTS

Mean growth strain values ranged from 28 to 160 um in standing trees (Figure 7). This suggested that there was a large range in growth stress and some very high stresses in comparison to other studies in *E. nitens* from Tasmania (see Figure 9) (unpublished).

Bow and board end splitting were the most important board characteristic potentially related to growth stress release. Spring was minor and recorded on very few boards. During board measurement there was no evidence to indicate further end splitting in boards as a result of the sawing process, and there was no evidence to indicate that splitting ahead of the saws occurred.

Bow

Figure 7 gives an indication of the severity of bow in relation to growth stress by showing maximum bow recorded on any board for each log and the mean growth strain for each log. This relationship had an $R^2 = 0.12$. (p<0.001) confirming that the growth strain measurements were an indicator of growth stresses. Ten boards of the total 815 produced in the trial had bow exceeding 100 mm over the 5.0 m length of the boards. It is important to note that this bow was measured with boards placed on their edges so it is greater than during normal transport on conveyer systems.

![Figure 7: Plot of maximum bow and mean growth strain NW-SE (R²=0.12, p<0.001).](image)

Neither the sawing pattern nor log diameter had a strong influence on the severity of bow. This is illustrated in Figure 8 which plots the mean bow for boards by location for each sawing pattern and with logs for each sawing pattern segregated into two equal sized groups based on the minimum SED (large and small diameter groups). The log groups are numbered 1-8 and the sawing pattern x diameter class that each number represents is given in Table 1. Also the board location is identified by width i.e. 101 mm wide is the outermost board: 160 mm wide is the second board from the log periphery: 200, 203, 220 mm wide (depending on sawing pattern) is the third board in from the log periphery.

Figure 8 indicates that there was greater bow in the smallest diameter group for sawing pattern 1 in comparison to the other groups. However, this was not statistically significant. In contrast bow declined as the distance of the board from the log periphery increased. Given this situation it may be expected that as the amount of wood chipped from the log periphery increased bow should decline. Therefore bow should have been reduced in the larger diameter group for each sawing pattern. The reason this did not occur is probably due to a combination of variation in log circularity and sweep which resulted in variable depth of cut with the chippers. Also growth stress severity probably varied around the log (Nicholson 1971).
Figure 8: Mean bow with 95% confidence limits for each board location and sawing pattern x diameter class based on the minimum SED.

Table 1: Sawing pattern x diameter class for logs groups 1 to 6

<table>
<thead>
<tr>
<th>Log group</th>
<th>Sawing pattern</th>
<th>Minimum SED range (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>22.0-23.9</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>24.0-26.0</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>24.0-25.9</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>26.0-28.0</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>26.0-27.9</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>28.0-32.0</td>
</tr>
</tbody>
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Some advantages of increased log length

The results for board end splitting are worth examining in detail. The photographs taken of the board ends at completion of sawing suggested that the board end splitting did not appear to worsen during sawing (as indicated above). However, there is another less obvious advantage of this sawing pattern over conventional processing methods. The recovery results before and after docking end splits (Figure 9) indicated that across the 6 sawing pattern x diameter class groups there was a recovery loss range of 1.0%-2.9% (bases on actual green board dimensions as a percentage of log volume). This compares to 5% recovery loss in a comparable processing trial in 22-year-old E. nitens where a conventional hardwood sawmill was used (Washusen et al. 2007b). This difference is a direct consequence of log length which was 2.7 m in the conventional mill and 5.0 m in the HewSaw trial. This is because the end splitting as a percentage of log length was less in the 5.0 m long logs. This was despite a tendency for greater log end splitting in the 17-year-old logs (Figure 10) which was significantly related to recovery loss due to board end splitting (p<0.001, R² = 0.18).

Log length also has implications for product value and the efficiency of board flow. Assuming the absence of defects that would require docking, logs at 5.0 m length produce longer average product length in comparison to the log lengths normally considered appropriate for conventional hardwood sawing systems. This should result in higher product value. There are also fewer boards to handle on the green chain for a given volume of wood, so in terms of wood volume, the capacity of the board handling system should be greater.
Figure 9: Mean recovery before and after docking end splits with 95% confidence limits for each sawing pattern x diameter class based on the minimum SED.

Figure 10. Plots of total split index (sum of large and small end) and growth strain for 17-year old *E. nitens* from Tumut in New South Wales; and 22-year old *E. nitens* for Goulds Country in northeast Tasmania. The split index is a function of log diameter and the length of the end split (Yang 2005).

**CONCLUSIONS**

There are advantages for application of the HewSaw R250 in processing plantation-grown eucalypts with high and variable growth stress levels, of which growth strain measured on standing trees can indicate.

Many board behavioural characteristics associated with growth stress release during sawing were uncommon or not observed. Specifically spring was uncommon, splitting ahead of the saws was not observed and there was no evidence to suggest that the sawing process
contributed to a worsening of end splitting and the resulting recovery loss from docking end splits on sawn boards.

The most common effect observed was bow. However, this was not severe and produced few difficulties on board conveyors and no problems for automated board stackers. The only observed difficulty was that two or three boards of the several hundred produced in the trial fell from steep conveyors. It is probable that this could be overcome with modification to the board handling systems by extending lugs or reducing the slope of conveyors. Obtaining an indication of the maximum allowable bow for the probable range of board conveyors and handling equipment for sawmills processing eucalypts would be useful for future evaluation.

End splitting of boards was another defect observed that may be associated with growth stress severity. However, this was primarily a consequence of harvesting and log handling which produced some log end splitting, and there was no evidence collected to suggest that sawing contributed to a worsening of end splitting on sawn boards. To the contrary there was evidence to suggest that losses in recovery as a result of docking end splits was reduced in comparison to conventional processing as a direct consequence of increased log length.

Overall the results suggest there are major advantages in application of HewSaw type technology in processing plantation-grown eucalypts. This is partly because the sawing method appears to control growth stress release to allow efficient processing. The other major advantages of these systems is their capacity for very high throughput and the capability for processing logs of much longer length than is generally accepted for conventional hardwood sawmills.

Future work should expand on these results to evaluate the financial efficiency of sawmills built specifically for processing eucalypts and compare these results with conventional hardwood sawmills.

The research should also be broadened to include other species and to assess the capacity of these sawmills to quarter-saw collapse prone eucalypts. It is possible with the HewSaw machines for flitches to be produced from the top and bottom of the cants that are thick enough to be quarter-sawn in a multi-rip resaw. The HewSaw SL 250 sawing line can process logs as short as 2.4 m which adds potential for this experimental approach to work.

REFERENCES


