Productivity and utilisation of an in-field chipping harvest system in an unmanaged blue gum coppice stand in Western Australia

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Introduction

Blue gum (\textit{Eucalyptus globulus}) plantation coppice is a low-cost reestablishment for a second rotation. Due to concerns over site productivity and harvest costs, coppiced stands are generally thinned early in the rotation to reduce the stocking to one or two vigorous stems per stump, resulting in a similar stocking to the original plantation and similar average tree sizes for harvest. Since this thinning activity early in the rotation involves a significant cost and a loss of potentially usable biomass, there is interest in leaving some stands unthinned—particularly those that will offer marginal returns—resulting in multiple stems per stump and a smaller average stem size. One of the key questions in the trade-off between a managed (thinned) and unmanaged (unthinned) coppice stand is the impact on harvest productivity. This bulletin explores the productivity and utilisation of an in-field chipping harvest system in an unmanaged blue gum coppice stand in Western Australia (WA).

Study and harvest system

The study site was a second-rotation site originally planted on ex-farmland in 1989 with a stocking of approx. 1470 stems per hectare (sph) with a final survival of 900 stems per hectare when harvested in November 1999. The trees received no silvicultural management for the whole of the second rotation. A compartment of 6.7 hectares (ha) within the plantation was selected for this study and consisted of a firm, even site (average 7\% slope) with the occasional rocky outcrop and a maximum skid distance of 500 m to the single landing site. The plantation is located 59 km east of the port of Bunbury (the destination of the woodchips) in the south-west of WA.

Since planting, several drought events had considerably reduced tree survival. A survey was undertaken prior to the coppice harvest to establish the number of surviving trees per hectare. Counting stools\textsuperscript{1} with one or more merchantable stems larger than 75 mm dbhob\textsuperscript{2} gave 527 trees/ha. Including stools with stems less than 75 mm gave 548 trees/ha. There were approximately three stems per stool, giving a total merchantable stocking of 1556 sph.

The standing merchantable volume calculated from delivery weighbridge data was 166 green metric tonnes per ha (GMT/ha). The average individual stem size equalled 0.11 m\textsuperscript{3}, with a combined merchantable volume of 0.315 m\textsuperscript{3} per tree. The first-rotation harvest had an estimated average stem size of 0.24 m\textsuperscript{3}. Pre-harvest inventory on the second-rotation coppice determined the average dbhob to be 11.9 cm with an average tree height of 19.3 m.

The second-rotation yield, although 25\% less than the first rotation, was still reasonably productive and produced export-quality woodchips.

\textsuperscript{1} A stool is the original stump of each tree from the first rotation.  
\textsuperscript{2} Diameter at breast height over bark.
Table 1. Yield differences between first and second rotations

<table>
<thead>
<tr>
<th>Harvest</th>
<th>Delivered chips (GMT)</th>
<th>Age (yrs)</th>
<th>Yield (GMT/ha)</th>
<th>Harvested trees (stools)</th>
<th>Ave GMT/tree (stool)</th>
<th>Mean Annual Increment (MAI) (GMT/ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1R approx.</td>
<td>1477</td>
<td>10.4</td>
<td>220</td>
<td>900</td>
<td>0.24</td>
<td>21.2</td>
</tr>
<tr>
<td>2R</td>
<td>1116</td>
<td>10.6</td>
<td>166</td>
<td>527</td>
<td>0.31</td>
<td>15.7</td>
</tr>
<tr>
<td>Difference</td>
<td>−361</td>
<td></td>
<td>−54</td>
<td>−373</td>
<td>0.07</td>
<td>−5.5</td>
</tr>
<tr>
<td>% difference</td>
<td>−24%</td>
<td></td>
<td>−25%</td>
<td>−41%</td>
<td>29%</td>
<td>−26%</td>
</tr>
</tbody>
</table>

Harvesting was carried out using an in-field chipping system, consisting of a Peterson Pacific 5000G delimber-debarker-chipper (DDC); a Tigercat 724D rubber-tyred, drive-to feller-buncher with a hot-saw; a Tigercat 630C rubber-tyred grapple skidder; and a Volvo L90E loader (see Figures 1 and 2). The debris was collected from the chipper by the loader and put into a pile adjacent to the roadside. The skidder did not remove the slash produced by the chipper, leaving it to keep the chipper supplied with wood, and occupied with associated decking and clearing activities.

Figure 1: Tigercat feller-buncher with hot-saw

Figure 2: Tigercat grapple skidder with chipper and loader in background

Figure 3: Location of study site (Maps courtesy of WAPRES)
Study method

The study combined shift-level time collection for all the machines (including trucks) and activity sampling by instantaneous observations for the harvesting machines only. Productivity of the system was measured by the weight of woodchips delivered across the weighbridge at the port facility and by using productive machine hours excluding all delays (PMH₀) and productive machine hours including delays up to 15 minutes (PMH₁₅). For the determination of utilisation rates and availability, on-site time for the harvest crew was the target shift length (i.e. not including travel time), even though in this particular operation travel time was included in the shift. Including travel time was seen as an added variation not linked to the system or harvest condition that would make the results more difficult to compare to other sites.

Results

Table 2 shows a relatively low productivity for the equipment in the harvest system. As there was only one of each machine in the study, except for the trucks, it is important to note that the felling was decoupled from the extraction phase. Given that the feller-buncher only worked half the time of the other harvest equipment, the feller-buncher’s utilisation and productivity would have been greatly reduced if it was limited by the rest of the system.

Table 2: Machine productivity

<table>
<thead>
<tr>
<th>Machine</th>
<th>GMT/PMH₀</th>
<th>GMT/PMH₁₅</th>
<th>GMT/SMH</th>
<th>Total site time (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feller-buncher</td>
<td>55.7</td>
<td>55.1</td>
<td>40.1</td>
<td>27.8</td>
</tr>
<tr>
<td>Skidder</td>
<td>27.9</td>
<td>26.8</td>
<td>21.7</td>
<td>51.5</td>
</tr>
<tr>
<td>Loader</td>
<td>34.3</td>
<td>29.4</td>
<td>21.3</td>
<td>52.5</td>
</tr>
<tr>
<td>Chipper</td>
<td>32.6</td>
<td>36.4</td>
<td>20.4</td>
<td>54.6</td>
</tr>
<tr>
<td>Truck</td>
<td>7.2</td>
<td>7.0</td>
<td>6.5</td>
<td>162.0</td>
</tr>
</tbody>
</table>

SMH = Scheduled Machine Hours

Figure 4 shows relatively high results, though not unreasonably so, for both availability and utilisation rates of the equipment, which is likely due to the short observation period (one week). The high utilisation rates suggest that the lower productivity results may be due to the smaller stem sizes being harvested in the unmanaged coppice.

Figure 4: Recorded availability and utilisation by machine

[Diagram]

3 Availability is the percentage of time the machine is ready to work within the bounds of the defined shift time. Utilisation is the percentage of time the machine actually works within the bounds of the defined shift time.
Figure 5 (below) shows that almost half of the feller-buncher’s time was taken up in felling trees. This is significantly lower than feller-bunchers operating on planted sites, where typically approx. 90% of productive time is felling and bunching. This result can be attributed mainly to the stocking differences evidenced by increased moving and travel times, but also to tree form (stools of significant size are slower to fell) and to machine type (rubber-tyred drive-to vehicles compared to tracked vehicles with boom-mounted heads). Also, the proportion of time lost in repair and maintenance and waiting is not measured in comparative studies. This productivity is, however, higher than for a short study conducted on this machine in a managed coppice stand. In this study, just under 30% of the time was lost to delays and scheduled maintenance, times that are more realistic for shift-level studies compared to detailed time-and-motion studies of shorter duration.

Figure 6 shows that 58% of the skidder’s time was used in travelling and loading. The skidder study resulted in a slightly higher loss to delays than the feller-buncher.

Figure 7 shows that nearly 50% of the loader’s time was lost to delays and scheduled maintenance. This was almost entirely due to the availability of the chipper. Figure 8 shows that the chipper spent only 54% of the shift time chipping wood. The 10% of time lost waiting for trucks or wood could have been avoided had supply been maintained. During this study, 27% of shift time was lost in mechanical breakdowns and operational delays (equally split). These delays do not include waiting for trucks or wood, or the 9% of time spent performing planned repairs and maintenance such as knife and chain changes and refuelling.

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Figure 5: Study times for the feller-buncher

Figure 6: Study times for the skidder

Figure 7: Study times for the loader

Figure 8: Study times for the chipper
The trucks spent their time equally amongst on-site time, travelling loaded and travelling empty, as is shown in Figure 9. Two-thirds of the on-site time was spent being loaded by the chipper.

Figure 9: Study times for the trucks

Take-home messages

- Subsequent coppice rotations of unmanaged blue gum plantations on marginal sites can be productive and can produce export-quality chips.
- Combining a bunching saw with skidder extraction and in-field chipping can produce reasonable machine productivity on a machine-by-machine basis, and on a harvesting-system basis. The somewhat lower harvesting productivity increases the harvesting costs, and these costs need to be balanced against the savings achieved through minimal plantation silviculture.
- The availability of the chipper (and supporting infrastructure) is the key to obtaining acceptable harvesting productivity from plantation-grown blue gum, irrespective of whether it is from planted stands or from unmanaged coppice stands with reasonable yields.
- Obtaining longer term machine observations using on-board computers could assist managers ensure effective utilisation of harvesting machinery in similar conditions.

Organisations supporting this research

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More information

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