Manual Harvesting Project

Report for the Box Ironbark Project

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Victoria

June 2006
Summary
This manual harvesting trial was carried out on a 2.5 hectare Eucalyptus globulus (Blue Gum) plantation and was conducted on a scale that would be considered a commercial operation. Falling and docking of cull trees into 2.5 metre long billets was carried out using a chainsaw. Extraction was carried out by loading the billets onto sleds dragged behind a vehicle, while processing was done by manually docking the billets into firewood length blocks on a saw bench type firewood mill.

![Figure 1. Typical unthinned Eucalyptus globulus (Blue Gum) plantation.](image)

The productivity of each individual operation was calculated for a range of productivity levels and labour costs and the individual results combined to give a total cost of production expressed in $/tonne of air-dry firewood (15% moisture content).

For a labour cost of $25/hr, the production cost ranged from $109 to $141/tonne with an average of $121/tonne. This firewood did however have its bark attached, and the bark was found to constitute approximately 15% of the air-dry weight. When the wood only component was calculated, then the production cost increased from $128 - $165/tonne averaging $143/tonne. There was however no allowance made in this calculation for the costs associated with the removal of the bark from the wood.

The profitability of the production process was assessed by comparing the cost of production to the local retail price of Eucalyptus camaldulensis (River Red Gum) firewood currently delivered to local households for between $130 and $170/tonne. By coincidence, the production cost of Blue Gum firewood (bark off) in this trial closely aligned with the price of local Red Gum firewood, however, delivery costs must be considered for it to be fully comparable.

As a result of the trial, there were some ways identified in which the cost of production could have been reduced. The major one of these was the use of a stationary motor to replace the tractor used to power the saw bench. The lower associated running cost would have reduced the cost of production to a range of
between $93 and $123/tonne averaging $104/tonne for firewood with bark on or $109 to $144/tonne averaging $123/tonne for firewood with bark off.

The results from this trial indicate that the production of air dry firewood from Blue Gum plantation thinnings using predominantly manual systems can be a viable activity, but it will require efficient practices to achieve a level of profitability acceptable for a commercial firewood enterprise.

**Background.**
Funding to conduct a “Small-scale Mechanically Harvesting Project” was obtained through the North East Box Ironbark Project. Initial investigations determined that the productivity of suitable small-scale machinery was not likely to be high given the piece size of the trees available as thinnings. Consequently, the cost of small-scale mechanical harvesting, extraction and processing was likely to exceed the return from the end product and so it would not be financially viable. Subsequent investigations to find more suitable small-scale mechanical harvesting equipment determined that due to its high cost and the level of financial risk involved, the project could not proceed with the level of resources available and so the small-scale mechanical harvesting project was abandoned.

The results from the work of some earlier small manual harvesting trials provided the impetus to develop a comprehensive manual harvesting trial to determine under what conditions a manual system would be a viable option for thinning eucalypt plantations.

**Methodology**
The trial was conducted on an unthinned plantation of Eucalyptus globulus (Tasmanian Blue Gum) planted in 1997 and being managed for sawlog production. The trees were 8 years of age at harvest. The site was flat with rows spaced at 4 metre intervals and trees spaced at 2.5 metres along the row. In all 21 rows of trees were included in the trial area, which was 2.5 hectares in size.

The trial consisted of three separate operations, (a) falling and docking, (b) extraction and (c) processing.

**Falling and Docking**
Cull trees from a first thinning operation in a Eucalyptus Globulus (Tasmanian Blue Gum) sawlog plantation were manually fallen, delimbed and docked to lengths of 2.5 metres using one experienced faller and a chainsaw. Where it was possible to cut a second length of 2.5 metres from the fallen tree, this was done. The fallen trees were orientated such that two rows of trees were fallen into the space between them, leaving the docked logs visibly exposed to aid extraction. This resulted in every
second space between the rows being left clear of debris allowing for easy vehicle access and to aid log extraction. The time taken to fell the trees and dock the logs to length were recorded for each row of trees fallen. Refuelling and sharpening of the chainsaw was included in the times recorded.

**Extraction**
The logs were extracted by manually loading them onto sleds, which were towed behind a vehicle. The use of a log hook shown in Fig.3 greatly assisted in handling the billets.

When loaded, the sleds were towed out of the plantation to an adjacent area where the logs were stacked. One person carried out the whole extraction process doing all of the driving, loading, unloading and stacking of the logs.
Individual times were recorded for the processes of travelling between the log stack and the plantation, and also the loading and unloading of the logs. The logs from each individual row of trees were placed in separate stacks to aid in recording and future use of data. The logs from some rows of trees were further segregated in order to determine some specific results (e.g. logs with large end diameters greater than 12 cm and logs with large end diameters less than 12 cm).

Processing
Stacked logs were processed into firewood. The logs were manually loaded from the log stack onto the bench of a firewood mill driven by a 45 HP diesel tractor. The logs were then manually pushed onto a circular saw blade where they were docked into 275mm (11-inch) lengths. This length was decided upon after discussions with a firewood merchant who specifies this length for the firewood he purchases. Although the firewood mill had the capacity to automatically split the larger logs, this facility was not used as it was thought that for the purposes of experimental comparison, splitting the larger logs may add a degree of complexity that would be difficult to
factor into the final results. As each block of firewood was cut from the log, it was automatically pushed forward onto the firewood mills conveyor from where it was then loaded into a tipping tray truck of 5 tonnes load capacity. The time taken to process each log pile was recorded. After each log pile had been processed, and was loaded onto the truck, the resulting firewood was weighed over a weighbridge and the weight of the firewood recorded. The time taken for firewood mill maintenance, refuelling the tractor and positioning of machinery in readiness for processing were not recorded or taken into account.

**Additional data collection**
Moisture content readings of the firewood were carried out during processing by placing a moisture meter on the freshly exposed cut from randomly selected blocks of wood of various diameters and from different wood stacks. The accuracy of moisture meters has been questioned in recent times, and so 12 blocks of wood were randomly selected, weighed, and placed in a drying oven set at 103°C. These blocks remained in the oven until their weight stabilised and no further weight loss occurred. The blocks were then reweighed and their moisture content calculated. For the purpose of standardisation, all weights were converted to 15% moisture content, the moisture content that is acceptable to firewood users, and at which firewood is considered to be “seasoned”.

**Results**
The trial thinned around 2.5 hectares of Eucalyptus globulus (Tasmanian Blue Gum) plantation and was conducted on a scale that was considered to be replicating a commercial operation.

**Falling and Docking**
An experienced faller was engaged during June and July of 2005 to fall all cull trees in 21 rows of plantation trees and to then dock these trees into 2.5 metre long billets. The time taken to fall and dock to billet length each row of trees was recorded and used to determine the productivity of the faller, which was then related to the cost of production. The productivity of the faller ranged from 0.51 to 0.71 tonnes/hr of air-dried wood (15% moisture content), averaging 0.62 tonnes/hr. Production costs for various labour rates and a fixed chainsaw cost of $3.35/hr are shown in Table 1.

<table>
<thead>
<tr>
<th>Cost of labour ($/hour)</th>
<th>$20</th>
<th>$25</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Low productivity (0.51 tonnes/hr)</td>
<td>$45.78</td>
<td>$55.59</td>
<td>$65.39</td>
<td>$75.20</td>
<td>$85.00</td>
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<tr>
<td>Average productivity (0.62 tonnes/hr)</td>
<td>$37.66</td>
<td>$45.73</td>
<td>$55.79</td>
<td>$61.85</td>
<td>$69.92</td>
</tr>
<tr>
<td>High productivity (0.71 tonnes/hr)</td>
<td>$32.89</td>
<td>$39.93</td>
<td>$46.97</td>
<td>$54.01</td>
<td>$61.06</td>
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</tbody>
</table>

Table 1. The cost of falling and docking cull trees ($/tonne@15% moisture content) for a range of labour costs, levels of productivity and with a fixed chainsaw cost of $3.35/hr.

**Extraction**
The technique used to extract the billets from the plantation was based on the sled system described by Mt Lofty Ranges Private Forestry Inc in their paper “Viable
small-scale firewood harvesting and processing using low cost sleds”. Several sleds measuring 2.4 metres in length and 1.8 metres in width were manufactured and used for the trial. Two sleds were linked together and towed behind a Toyota Hilux 4WD in low range four wheel drive. The low profile of the sleds allowed easy loading of the 2.5 metre long billets, which were picked up at one end with a log hook and dragged across the sled. Because the tree rows were spaced at 4 metre intervals, there was sufficient clearance between the rows to allow easy passage of the sleds between the rows. Each sled carried approximately 500-kg weight and in dry conditions the Hilux was able to drag two sleds linked together. In the later part of the trial, a 45HP 2WD tractor was used to drag the sleds. With rainfall, soil conditions changed, and it appeared that it was now more difficult to drag the sleds.

For each row of trees, the time taken to load and unload the sleds and the time taken to travel between the log dump and the plantation were recorded. On average, 4 sleds of billets were extracted in two trips (2 x 2 sleds) from each row of trees. The load on each sled averaged 585 kilograms, so the vehicle was required to tow 1.17 tonnes of billets. Each trip took around 22.5 minutes to load the sleds and 13 minutes to travel between the plantation and the log dump.

Productivity and extraction costs were calculated ignoring the time taken to unload the billets from the sleds. It was assumed that in a streamlined commercial operation, the billets could be processed directly from the sled or the sled could be designed to tip off the billets in less than a minute, minimising the unloading time. The extraction vehicle was assumed to be a 45 HP tractor valued at $45000. Using the method described by Miyata (1980) to determine machinery operating costs, the hourly hire rate for the tractor was calculated to be $28/hr.

For this trial, the productivity for manual extraction averaged 1.95 tonnes/hr with a range of between 1.53 and 2.33 tonnes/hr. In Table 2, the cost of extracting billets is calculated for a range of labour costs and levels of productivity, but assumes a fixed cost for the operation of a tractor.

<table>
<thead>
<tr>
<th>Cost of labour ($/hour)</th>
<th>$20</th>
<th>$25</th>
<th>$30</th>
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<tbody>
<tr>
<td>Low productivity</td>
<td></td>
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<tr>
<td>(1.53 tonnes/hr)</td>
<td>$31.37</td>
<td>$34.64</td>
<td>$37.91</td>
<td>$41.18</td>
<td>$44.44</td>
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<td>Average productivity</td>
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<td></td>
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<tr>
<td>(1.95 tonnes/hr)</td>
<td>$24.62</td>
<td>$27.18</td>
<td>$29.74</td>
<td>$32.31</td>
<td>$34.87</td>
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<td>High productivity</td>
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</tr>
<tr>
<td>(2.33 tonnes/hr)</td>
<td>$20.60</td>
<td>$22.75</td>
<td>$24.89</td>
<td>$27.04</td>
<td>$29.18</td>
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</table>

Table 2. The cost of extracting billets ($/tonne@15% moisture content) from a Eucalyptus globulus plantation for a range of labour costs, levels of productivity and a fixed tractor cost of $28/hr.

Processing
The processing of the billets into firewood was carried out using an automatic firewood mill capable of cutting, splitting and loading the wood directly into a tipping tray truck. As a large proportion of the wood did not require splitting and as it was
thought that splitting could add a degree of complexity to the analysis of data, a decision was made not to split the larger blocks of wood.

In this trial, the productivity of processing is dependent upon two major factors. These are (a) the diameter of the billet being processed and (b) the speed at which the billet can be put through the firewood mill.

Of the three separate operations, the processing productivity had the least variation. The average processing productivity was 1.35 tonnes/hr, with a range of between 1.23 and 1.4 tonnes/hr. Table 3 shows the cost of processing billets into firewood for a range of labour costs, but a fixed operating cost for the processing equipment. The equipment operating costs have again been calculated using the method described by Miyata (1980), with the tractor driving the processor costing $28/hour and the processor costing $9.50/hour.

<table>
<thead>
<tr>
<th>Cost of labour ($)</th>
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<th>$25</th>
<th>$30</th>
<th>$35</th>
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<td>$50.81</td>
<td>$54.88</td>
<td>$58.94</td>
<td>$63.01</td>
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<tr>
<td>Average productivity (1.35 tonnes/hr)</td>
<td>$44.57</td>
<td>$48.45</td>
<td>$52.33</td>
<td>$56.20</td>
<td>$60.08</td>
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<td>High productivity (1.4 tonnes/hr)</td>
<td>$42.59</td>
<td>$46.30</td>
<td>$50.00</td>
<td>$53.70</td>
<td>$57.41</td>
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</table>

Table 3. The cost of processing billets into firewood ($/tonne@15% moisture content) from a Eucalyptus globulus plantation for a range of labour costs, levels of productivity and a fixed processor operating cost of $37.50/hr.

Proportion of wood to bark
All operations in this trial have been carried out on timber carrying its bark. One year after the trees were fallen and cut into billets the majority of the bark was still firmly attached to the billets. As a consequence, all of the results above are for timber with its bark on. Removing the bark from some samples of wood determined that as a percentage of air dried material (15% moisture content), bark forms around 15% of the total weight.

Total Cost
The actual cost of producing one tonne of air-dried firewood is easily calculated by adding the costs of the three different operations. Table 4 provides this information for a range of labour costs and levels of productivity. It also provides costs for the wood only component if the bark could be removed. It does not take into account the cost of removing the bark.
## Discussion

The aim of this trial has been to determine if it is viable to produce firewood from a manual thinning operation carried out in a Eucalyptus globulus (Tasmanian Blue Gum) plantation. In the past, these plantations have been thinned to waste and the thinning operation has been at a cost to the plantation owner of about $300/hectare. Conducting this trail has resulted in over 44 tonnes of air-dried firewood being produced from 2.5 hectares of 8-year-old plantation and has been of a scale large enough to replicate a commercial operation.

The viability of producing firewood is determined by the financial bottom line. What does it cost to produce the firewood? What price can be achieved when the firewood is sold? Is there a profit to be made?

For this trial, the cost of producing one tonne of air-dried firewood under various conditions is shown in Table 4. How do these prices compare to firewood currently being sold on the open market? Comparison is difficult as firewood is sold by many different measures. The most common measure is the “cubic metre”, which usually refers to a loaded 6 x 4 trailer with the box of the trailer stacked to a height of about 0.5 metres. Locally, Eucalyptus camaldulensis (River Red Gum) is the most commonly sold firewood, and its retail sale price ranges from $65 - $85 per cubic metre delivered to the purchaser. In suburban Melbourne, River Red Gum is selling for a retail price of up to $225/tonne.

Appendix B of the Victorian Firewood Strategy Discussion Paper (DNRE 2002) provides comparisons for units of measure. From the discussion paper and for the purpose of this discussion, I have adopted the measure of a 6x4-trailer load weighing 0.5 tonnes.

Using local retail prices gleaned from newspapers, River Red Gum firewood is selling for between $130 to $170/tonne, delivered to the purchaser. Assuming some additional expense for delivery, the cost of production for Blue Gum firewood from this trial (see Table 4) compares favourably where the labour cost is in the vicinity of $20-$30/hr. Once labour costs rise above this rate, then the cost of production will increase to a point where it becomes equivalent to the price of River Red Gum. As

### Table 4. The total cost of producing one tonne of “bark on” air-dried firewood (15% by weight bark & 15% moisture content) from the thinnings of an 8 year old Eucalyptus globulus (Tasmanian Blue Gum) plantation using manual falling, docking, extraction and processing practices for a range of labour costs and levels of productivity. The figures in brackets are the total costs for the wood only (no bark) component with no cost included for the removal of the bark.

<table>
<thead>
<tr>
<th>Cost of labour ($/hour)</th>
<th>$20</th>
<th>$25</th>
<th>$30</th>
<th>$35</th>
<th>$40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low productivity (Wood only - no bark)</td>
<td>$123.90 ($145.28)</td>
<td>$141.04 ($165.30)</td>
<td>$158.18 ($185.31)</td>
<td>$175.32 ($205.33)</td>
<td>$192.45 ($225.35)</td>
</tr>
<tr>
<td>Average productivity (Wood only – no bark)</td>
<td>$106.85 ($125.72)</td>
<td>$121.35 ($142.76)</td>
<td>$135.86 ($159.79)</td>
<td>$150.36 ($176.82)</td>
<td>$164.87 ($193.86)</td>
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<tr>
<td>High productivity (Wood only – no bark)</td>
<td>$96.08 ($112.52)</td>
<td>$108.97 ($127.59)</td>
<td>$121.86 ($142.66)</td>
<td>$134.76 ($157.73)</td>
<td>$147.65 ($172.80)</td>
</tr>
</tbody>
</table>
River Red Gum has an established reputation as a premier firewood species, it is likely that consumers would purchase it in preference to plantation grown Blue Gum.

Are there ways the production costs for this trial could have been decreased? The answer is “Yes”! If the firewood mill had been fitted with its own stationary engine to drive it, then the hourly cost of the processing machinery would have been reduced from $37.50/hour to $15.55/hour (again using the methodology of Miyata to calculate machinery costs). Table 5 shows the effect that this would have on decreasing the cost of production (and increasing the profitability).

<table>
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<tr>
<th>Cost of labour ($) (hour)</th>
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<tr>
<td>Low productivity</td>
<td>$106.06</td>
<td>$123.20</td>
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<td>$157.47</td>
<td>$174.61</td>
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<td>(Wood only - no bark)</td>
<td>($124.17)</td>
<td>($144.19)</td>
<td>($164.21)</td>
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<td>Average productivity</td>
<td>$89.83</td>
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<td>$118.84</td>
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<td>$147.85</td>
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<td>(Wood only – no bark)</td>
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<td>($122.62)</td>
<td>($139.65)</td>
<td>($156.69)</td>
<td>($173.72)</td>
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<tr>
<td>High productivity</td>
<td>$79.82</td>
<td>$92.71</td>
<td>$105.61</td>
<td>$118.50</td>
<td>$131.39</td>
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<tr>
<td>(Wood only – no bark)</td>
<td>($93.43)</td>
<td>($108.50)</td>
<td>($123.57)</td>
<td>($138.64)</td>
<td>($153.71)</td>
</tr>
</tbody>
</table>

Table 5. The estimated total cost of producing one tonne of air-dried firewood (15% moisture content) by replacing a tractor powered firewood mill with one driven by a 22 HP stationary engine. The figures in brackets are the total costs for the wood only (no bark) component with no cost included for the removal of the bark.

Billet volume also plays a significant role in productivity. In two rows of plantation, billets with a large end diameter (LED) greater than 12cm were extracted and processed separately from those billets with an LED less than 12cm. Processing billets with an LED greater than 12cm improved productivity (tonnes/hr) by 18% over those billets with an LED less than 12cm. This implies that if only billets with LED’s greater than 12cm were harvested, then an 18% increase in processing productivity would have resulted, and a reduction in the cost to produce one tonne of firewood of around $8-10/tonne would be possible.

In a word of caution however, when the LED of billets nears 25cm, the billets are becoming too heavy for manual handling and a mechanised lifting system would need to be considered. Incorporating this type of machinery into the operation will change the economics and this would need to be taken into account.

Further efficiencies could have been achieved if the processing area had been located closer to the area being thinned. Because the log dump was located some 250 metres from the harvested trees, travelling time would have been reduced if the log dump had been at the edge of the harvested area. Modification of the sled to reduce dragging resistance would also have reduced the time taken for travelling.

Plantation layout also has a role to play in productivity. The trial plantation was laid out in straight rows that were evenly spaced. Plantations established on contours often have rows running into each other that result in confusing clearways, slowing traffic movements and the extraction process.
Of course, the other way of increasing profitability is to increase the sale price of the firewood. It is possible that this could be done through developing a packaged firewood product that would command a higher $/tonne retail price.

**Conclusion**

This trial has shown that under certain conditions it will be viable/profitable to manually produce firewood from the thinnings of Eucalyptus globulus (Blue Gum) plantations.

These conditions include:

- Billets should have a large end diameter no smaller than 12cm and no greater than 25cm.
- Log dumps should be located as close as possible to the harvested area to reduce travel time and therefore cost.
- The use of low cost sleds (or other devices) in the extraction process, which are easy to load and cheap to construct. This means that when loaded, several can stand around allowing the processing to be done directly from them, reducing the labour costs required for unloading.
- Machinery used should be of the smallest size that will allow the job to be done with ease. This reduces the operating costs of machines, particularly replacement and fuel costs which in turn keeps the cost of production low.
- The cost of labour will need to be in the vicinity of $20-25/hr for the operation to be profitable.
- Care must be exercised in the allocation of labour to individual tasks. For example, in the area of processing, having a person assist in loading the billets onto the firewood bench will not lead to doubling processing productivity, however, it will double the cost of labour. The ideal system would be to have either two or three labour units each doing an individual operation, occasionally changing roles to ease repetitiveness of tasks. In any case, for safety reasons, there should be at least two persons working together or in close proximity to each other.

**References**

“Viable small-scale firewood harvesting and processing using low cost sleds”
