Effects of different stocking densities on harvesting of bluegum stands in Western Australia – Ayres 00 case study

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Introduction

This bulletin presents the results of a harvesting trial conducted near Greenbushes, Western Australia (WA) in December 2011. It corresponds to the second harvesting trial of this type conducted by AFORA in bluegum plantations, whose objective was to assess productivity and cost related to tree form and stocking density of 400, 550 and 1000 stems per ha (spha) created by removal of malformed, undersize and competing stems. The trial also forms part of a large-scale AFORA project focused on the comparison of WA blue gum harvesting systems designed to define the optimal harvesting system choice relative to local stand and site conditions.

Study area and research methods

- The study site was planted with bluegum (*Eucalyptus globulus*) at 1000 spha (5m x 2m) in June 2000 and a stocking trial was subsequently established on the site in October 2002 (2 years and 3 months after establishment) to assess the impact of stocking density on tree growth and stand production.
- Nine sample plots of 880 m^2 were laid out randomly in the plantation and was thinned to a stocking of 550 and 400 spha. Control (unthinned) nominal stocking was 1000 spha. The thinning treatment targeted undersize and poor form trees (resulting mainly from parrot damage) as a priority.
- The harvesting trial occurred during final felling of the site in December 2011 (11 years and 5 months after establishment). Harvesting was carried out using a tracked excavator-based Volvo 210 (H21) harvester equipped with a 16-inch Waratah 616c head. The harvester operator had 10 years of experience working with similar equipment. Product specification focused on the production of 3 to 6m debarked chiplogs with a maximum large-end diameter of 560mm, and a small end diameter if 50mm
- Harvester's cycle elements were timed on a tree-by-tree basis during harvesting of all 9 plots. On average, treatment plots measured 0.088ha and the operator worked along strips comprised of three rows at a time.
- Every tree in the treatment plots was measured prior to harvest and subjectively assessed as to the expected impact of three major form criteria (branching, forking and sweep) on harvester productivity.
- The site was relatively flat with an average slope of 9°. The soil was dry and deep, while the ground was stable and even, and clean of understory vegetation.

Results

Tree and Stand Factors

Table 1 summarises the tree growth and stand production for trees within stocking treatments. It is evident that the spacing treatment at age 2 had significant impact on tree growth. Average over bark diameter at breast height (DBHob) increased by 34% when moving from the control (unthinned) stocking down to 400 spha, and average tree height increased by 12%. Despite the impressive growth of trees within the spaced plots, overall stand production (in tonnes per hectare) did not catch up to that of the control sample plots in the eight years since thinning. Average final merchantable yield at the 400, 550 stocking densities was 17.1% - 11.7% less than the control, respectively.

Table 1. Tree and stand factors.

	Target Stocking (spha)		
Tree and stand factors	**400**	**550**	**Unthinned**
Number of treatment plots	3	3	3
Actual stocking (merchantable* spha)	400	525	826
Average tree diameter, mm (DBHob)	266	242	199
Average tree height, m	24.8	23.5	22.2
Average standing tree volume, m³/tree	0.55	0.44	0.33
Forking: % of merchantable trees in Class 1**	37	31	28
Branching: % of merchantable trees in Class 1**	22	13	10
Average merchantable yield, t/ha	218.3	232.7	263.4
Differential, %	-17.1	-11.7	0.0

* Merchantable trees are trees with at least one stem being >7.5cm dbhob with >3m straight bole. Dead, fallen or broken trees with bole <3m were deemed as non-merchantable for this study.
** Class 1: there is an expected impact of factor (branchiness or forking) on harvesting/processing productivity

The spacing treatment at age 2 targeting stems of poor form had a negative impact on overall stand form within the different stockings. In the control (unthinned) stocking, 28% of the stems had major forks compared with 37% in the 400 spha. Unfortunately, despite parrot control work post thinning, impact continued to occur on good form trees retained after the thinning of the worst formed trees. Although this proved to have some effect on relative harvesting efficiency, it was offset by the effect of a bigger piece size in the 400 spha. Heavy branching was more pronounced in the 400 spha and sweep was comparable among treatments but these factors were found to have a lesser impact on harvester productivity.

Productivity and cost

Table 2 summarises relative harvester productivity and estimated direct unit costs within the different stocking treatments. Harvester productivity was 33% higher and costs were 22% lower in the 400 stocking compared to the control (unthinned) stocking mainly as a result of the much larger average tree size. Table 3 shows the impact of forks and branches on productivity. While major forks were found to reduce harvester productivity by 16.2%, there were no important differences between trees with and without significant branching.

Table 2. Productivity and cost comparison

	Stocking (spha)		
	400	**550**	**Unthinned**
Average time per tree, minutes *	1.3	1.2	1.0
Average productivity, t/PMH_{15} **	25.2	23.1	19.0
Average harvesting cost,$/t ***	8.8	9.6	11.3
Differential, %	-22.1	-15.1	0.0
Average harvesting cost, $/ha ***	1919	2229	2971
Differential, %	-35.4	-25.0	0.0

* The average harvesting cycle was comprised of the following elements: felling (16%), processing (76%), move between trees (4%), clearing of unmerchantable trees and debris (<1%), stacking of logs (<1%), turnaround at end of strip (3%) and delays (<1%). Delays > 15 min. were not considered productive time and excluded from PMH.
** PMH_{15} considers short delays (less than 15 minutes) as part of productive time.
*** Based on an estimated hourly cost of $220/$PMH_{15}$ for the harvester, excluding overhead, supervision, profit, risk and relocation costs.

Table 3. Impact of forks and branches on productivity

	Forking class		Branching class	
	Class 0	**Class 1**	**Class 0**	**Class 1**
Average volume/tree, m^3	0.38	0.48	0.40	0.49
Average time per tree, min.	97.2	146.5	109.6	130.0
Differential, %	0.0	50.7	0.0	18.6
Productivity, m^3/PMH_{15}	22.9	19.2	21.7	22.3
Differential, %	0.0	-16.2	0.0	+2.8

Cost analysis of spacing treatment

When reducing stocking from 1000 to 400 stems per hectare, tree volume increases by 67% but overall stand yield reduces by 17%. As such, assuming a discount rate of 7%, a thinning treatment cost of $400/ha at age 2, a land leasing cost of $500/ha/year, a stand establishment cost of $1450/ha and the harvesting costs presented in this bulletin, a net loss of $4.5/tonne in present value is obtained for the stocking at 400 spha. When growth and cost implications are taken into account, the actual breakeven point of the treatment is achieved when stand yield reduces by no more than 2.3%. The same analysis with the 550 stocking gives a net loss in present value of $3.3/tonne and a breakeven point of 0.1%. Please note that this simple economic analysis does not consider all the possible cost implications of an early stand tending treatment, but merely provides an indication of the economic return.

Take-home messages

- Early thinning increased average diameter up to 34%, height up to 12%, and tree size up to 67% when moving from standard 1000 spha down to 400 spha. However, for the study site, final stand yield of the thinned stands did not catch up to that of the standard 1000 spha in the time given (age 2.3 to age 11.4).
- Increased tree volume from thinning increased harvester productivity by up to 33% and reduced direct harvesting costs by up to 22% when moving from standard 1000 spha down to 400 spha.
- Forking had the greatest impact on harvesting productivity. Major forks decreased harvester productivity by 16% on a per tree basis. Given the significant impact of forks, investment to mitigate forking in severely affected stands may be justified and major forking could be accounted for in the harvest rate.
- The cost analysis showed that all thinning treatments on this site resulted in a net financial loss over the full rotation of 11.4 years. Positive impacts on individual tree growth and associated reductions in harvesting costs did compensate for overall losses in per hectare yield within the time frame of this thinning trial.

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More information

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