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Comparing harvester productivity in third-row versus fifth-row thinning of a *Eucalyptus nitens* plantation

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Introduction

Sawlog production from *Eucalyptus nitens* plantations in Tasmania is becoming an important part of the industry. The plantations typically have a single, commercial thinning, primarily for pulp, at a nominal age of nine years to improve growth of final crop trees. Thinning is carried out as a combination of row thinning and the removal of small or poorly formed trees from the retained rows.

A thinning productivity trial was carried out in early 2009 by the CRC for Forestry and Forest Enterprises Australia (FEA) staff and one of FEA's harvesting contractors to:

- compare harvesting productivity between third-row and fifth-row thinning
- identify the causes of any productivity differences found
- identify opportunities to improve harvesting productivity in thinning operations.

Study description

The study area comprised approximately 11 hectares of gently sloping, former farmland in north-east Tasmania. *E. nitens* were planted here in 1999. During 2009, 4 hectares of the area had every fifth row harvested, while 7 hectares had every third row harvested. Both areas were thinned to FEA's specified stocking rate of 450–600 stems per hectare (sph).

Plots were established in the study area on a 100 m grid prior to thinning. Diameter at breast height (DBH) of every stem and each plot's dominant height were measured. Plots were revisited post-thinning to identify the number and size of retained and removed stems (Figure 1).

The harvesters studied were converted excavators with Waratah HTH616 harvesting heads (Figure 2). Harvesters thinned in one direction only. Forwarder performance was not studied in the trial as it was believed to be much less affected by thinning type. The harvester operators involved in the trial were experienced in conducting third-row and fifth-row thinning.

Harvester performance[1] was assessed by:

- instantaneous observations collected using a PDA to compare proportions of time used in each harvester activity, e.g. felling, processing, moving, etc. (Figure 3)
- analysis of GPS data collected with Multidat data loggers to compare machine speed when working (processing speed) and when returning to commence the next row (travelling speed)
- video records of the harvesters operating in the trial area to determine number of logs cut per minute, processing time[2] per log and the time taken to move the harvester head to the next tree (slower movement of the head to trees in the second retained row in fifth-row thinning was seen as a potential important difference between third-row and fifth-row thinning) (Figure 4).

Results and discussion

To cut the same number of stems in the same time using third-row and fifth-row thinning, harvesters must travel much faster (1.67 times) in third-row thinning as they have more distance to cover in third-row thinning.

[1] Most results were obtained only for the Hitachi harvester. Where results were obtained for both harvesters, no significant difference was found between them.
[2] Calculated by dividing the stem processing time by the number of logs cut from the stem.

Results of the third-row thinning trial showed that:

- processing speed was less than expected (~1.55 times the fifth-row thinning speed) (Table 1)
- this method produced 10% more logs per minute than in the fifth-row thinning (Table 1).

Further analysis found the lower harvester processing speed and higher log production to be the result of more sph having been cut in the third-row area (Table 2) and a faster mean processing time for each log in this area (Table 1). No explanation could be found for the faster log processing. When harvester productivity was adjusted to account for the differences in sph removed and log processing speed, there was no significant difference in harvester productivity between third-row and fifth-row thinning in this trial.

Silvicultural considerations were not a part of this study, but may also have an impact on deciding whether to apply third-row or fifth-row thinning.

Figure 1.
A plot after thinning

Figure 2.
Harvesters used in the study

Figure 3.
Collecting instantaneous observations

Table 1. Harvester performance measures (mean values)

	fifth row	third row
Logs cut per minute#	3*	3.3*
Processing time per log (seconds)	10.7*	10*
Processing speed (kmh)	0.11*	0.17*
Travel speed (kmh)	3.3	3.2

there was no significant difference in the mean number of logs cut from each stem between thinning treatments
* indicates a significant difference ($p<0.05$) between fifth-row and third-row thinning trials

Table 2. Pre- and post-thinning mean sph and DBH of each thinned area and dominant height

	fifth row			third row		
	pre-thin	post-thin	removed stems	pre-thin	post-thin	removed stems
Stocking (sph)	1071	668*	403	961	498*	463
Average DBH (cm)	20.1	21	18.9	20.2	21.4	18.9
Dominant height (m)	24.9*			22.7*		

* indicates a significant difference ($p<0.05$) between fifth-row and third-row thinning trials

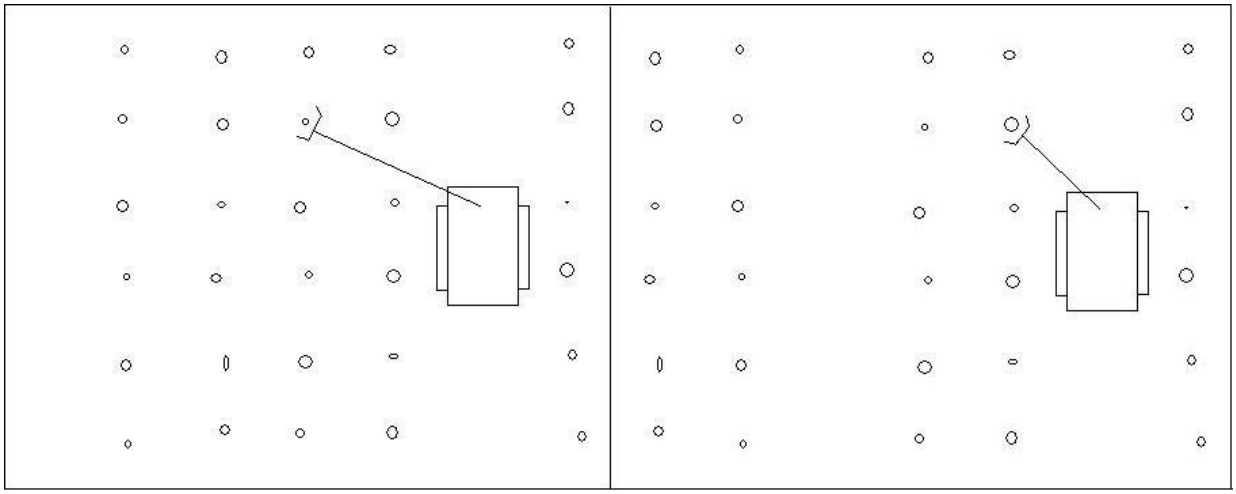

Figure 4.

Fifth-row thinning illustrating reaching into the second retained row (left) and third-row thinning (right)

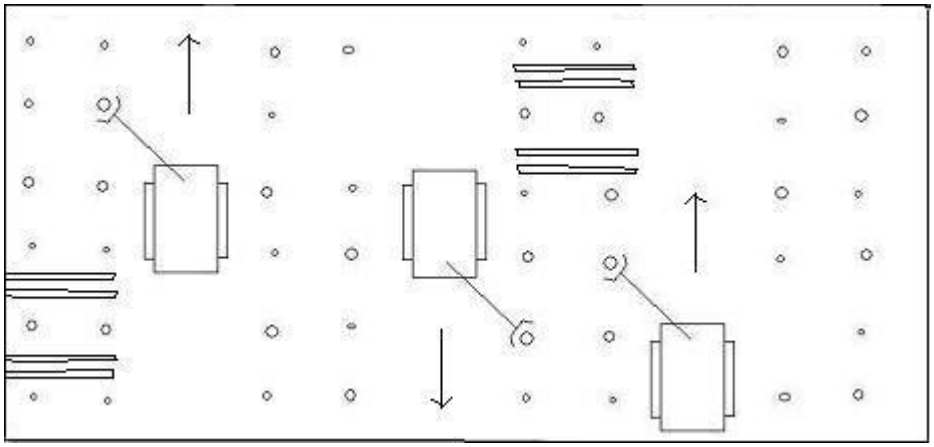

Figure 5.

Third-row thinning in both directions, illustrating the potential for log piles to encroach on the next removed row

Recommendations

During the trial, the following areas in which harvester productivity could potentially be improved were identified:

- **Thinning in both directions in fifth-row thinning**. Travelling back to start thinning the next row consumed approximately 4% of harvester productive time. If thinning occurred in both directions harvester productivity would be significantly improved.[3]
- **Avoid knocking down dead trees and small woody weeds** except where necessary for visibility or safety. Clearing accounted for 3 to 4% of harvester productive time.
- **Avoid reversing**. Reversing reduces productivity as machines have to cover the same ground twice.
- **Leave machines in the field if travel distance is excessive** to save travel time at the start and end of each shift rather than moving them to a central location. Use a car shuttle to travel to machines for service and refuelling. Travel times of up to 15 minutes were observed at the end of the shift during the trial (30-minute round trip).

Care should be taken in applying the results to other sites, particularly if the harvesting equipment or slope is different.

Take-home messages

- Harvester productivity was not significantly different between third-row and fifth-row thinning of nine-year-old *E. nitens* plantations in this trial.
- Harvester productivity could potentially be improved by changing work practices, specifically by:
    - thinning in both directions
    - leaving dead trees and small woody weeds during harvesting.

Organisations supporting this science

FEA provided in-kind support to carry out this research. Anthony Brown (Principal) and Noel Lockhart and Phil Spicer (harvester operators) of Mechanised Logging P/L carried out the thinning. This research project was supported by all contributors to Program Three ('Harvesting and operations').

More information

See the CRC for Forestry website:
http://www.crcforestry.com.au/research/programme-three/index.html

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[3] Operators process trees to the left of the harvester to maintain their line of sight as the cabins are on the left of the machine (Figure 2). Thinning in both directions and to the left of the harvester places cut logs on alternate sides of the removed row. In third-row thinning, cut stems may encroach on the next row to be removed (Figure 5). This problem does not occur in fifth-row thinning as four rows are retained between removed rows.