General productivity model for single grip harvesters in Australian *Eucalyptus globulus* plantations

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**Introduction**

The ALPACA decision support tool has been developed to assist the Australian forest industry with harvest planning, estimating harvest costs/rates and simulating harvest operations. However, it is largely based on overseas studies due to the lack of suitable Australian studies. Development of productivity models for eucalypt plantation harvesters was identified as a priority because the recent establishment of the Australian eucalypt plantation estate (largely post-1995 (Gavran & Parsons 2011)) means that few harvester productivity models have been developed for an estate that makes up almost 50% of the total Australian plantation resource.

Individual productivity models can be strongly influenced by factors specific to the study, particularly operator performance differences (Spinelli et al. 2010). General harvester productivity models aim to overcome this limitation by using a large pool of data to even out the influence of factors other than tree size (Spinelli et al. 2010) or by developing a series of models that explicitly include one or more important factors such as the operator, tree and site characteristics. Ideally, a productivity model should be produced with the least effort and the highest precision possible (Stampfer & Steinmüller 2001). Detailed time and motion studies can produce high-precision models, but can take days to establish, perform and analyse. In contrast, time and piece counts can collect relatively low-precision data from a large range of stand and site conditions, operators and machines in a relatively short period of time. Automated data collection is another option. However, many harvesters used in Australian eucalypt plantations do not collect data to the StanForD standard.

The objective was to develop a robust, general productivity model for single-grip harvesters performing cut to length (CTL) harvesting at the stump in short-rotation *Eucalyptus globulus* plantations in Australia. This model would then be used to improve the predictive abilities of the ALPACA decision support tool.

**Materials and methods**

The model was based on over 45 studies from CTL clearfell harvesting operations in short-rotation *E. globulus* plantations from south-west Western Australia and central Victoria. Sites were gently sloping with little undergrowth and few obstructions (typical of the Australian *E. globulus* plantation estate) and covered a range of mean merchantable tree volumes.

The studies were conducted using time and piece counts. For each study, several inventory plots of 30 - 40 trees in total were established in an area to be felled by the harvester. Diameter at breast height over bark (DBHOB) taken at 1.3m of every tree within the plot, and the height of approximately 10 trees per plot was measured. Mean merchantable tree volume was calculated using a single tree volume model supplied by the plantation manager, where available, or using a generic *E. globulus* tree volume model. Delay-free harvester productivity (m³/PMHₜₚₙ) was estimated by counting the number of trees felled and processed over a period of at least one hour to obtain trees cut per hour and then multiplying this result by the estimated mean merchantable tree volume.

Harvester productivity estimates were plotted against mean merchantable tree volume and a model fitted to obtain the best goodness of fit and homogeneity of variance of residuals.
Results

The model form that best fitted the harvester productivity data ($R^2 = 0.77$) and achieved homogeneity of variance of the residuals was a natural logarithm transformation of tree volume (Figure 1). The model was compared with harvester productivity estimates from overseas eucalypt plantations and 3 of the 4 productivity estimates fitted the model well (Figure 1).

![Figure 1: Productivity of sampled harvesters and published harvester productivity data against mean tree volume. Best fit model (derived from the sampled harvester data only) is shown.](image)

Conclusions

Data collected using time and piece counts covering a range of tree sizes, machine types and operators were used to rapidly develop a robust general single-grip harvester productivity model for Australian *E. globulus* plantations for inclusion in the ALPACA decision support system.

References


