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

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Overview

- Background
- Data collection approaches
- Study details and results
- Examination of the model
- Conclusions

Background

- Australia has over 900,000ha of eucalypt plantations, predominantly of *Eucalyptus globulus* (blue gum) established since 1990.
- There are few published harvester productivity models and *no general harvester productivity models* for these plantations

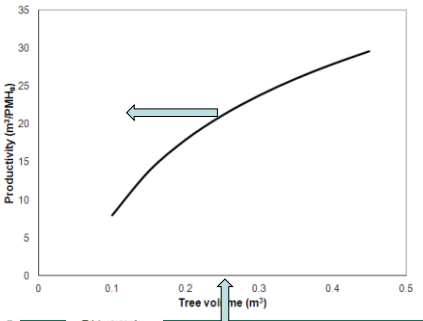
Source: http://www.panoramio.com/photo/20466913

Why develop a general productivity model?

- Single harvester studies can be strongly influenced by factors such as operator performance
- General harvester productivity models use a large pool of data to even out the influence of these factors

How will the model be used?

- Decision Support Systems (e.g. ALPACA)
- Direct use of the model



Source: www.smh.com.au

Who will use the model?

- Researchers
- Forest growers
- Harvesting contractors

ALPACA

- ALPACA = Australian Logging Productivity And Cost Appraisal model
- Initially based largely on results of non-Australian production studies
- Current study is part of the effort to populate ALPACA with Australian production studies

Data collection – potential approaches

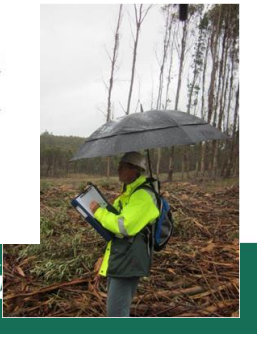
- Time and motion studies
- Automated data collection
- Time and piece counts

Data collection – Time and Motion

- Can produce detailed results.
- *But,* can be costly, time consuming and limited in scope

"According to our time-and-motion studies, you handle your time very well but a lot of your motion is wasted."

Source: commerceedu.wordpress.com



Data collection –automated

- Potentially a good way to collect data for a general harvester productivity model, *but:*
  - Most harvesters in the study could not collect StanForD data

Data collection – Time and piece counts

- Can collect a large number of harvester productivity estimates in a short period of time
- Relatively low cost
- Data can be collected opportunistically
- *But:* lower precision than T&M study results

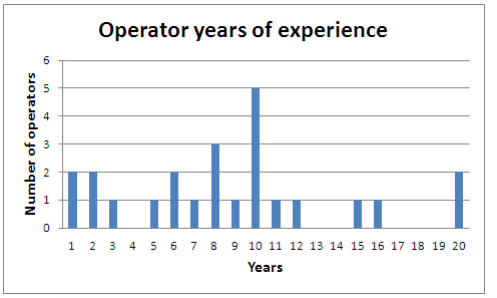
Study details and results

Study sites

- Sites were flat or gently sloping with trees of good form and little undergrowth or obstructions
- Plantation age was generally about 10 years
- Trees were clearfelled for pulplogs (~5m logs)

Operators

- 24 operators studied
- Majority of operators had 5 years or more experience



Harvesters

- 21 harvester base/head combinations studied
- Majority:
  - Medium-sized (100-180kW) excavator-based machines (mainly Cat/Volvo)
  - Equipped with small Waratah heads (HTH616, HTH618, HTH620)

Source: www.waratah.net

Study data collection – Time and piece counts

- Time and piece counts were mostly of 1-2 hours duration (46 T&P counts in total)
- Mean tree volume estimated from plots of 20-30 trees ahead of the harvester
- Productivity estimated by:

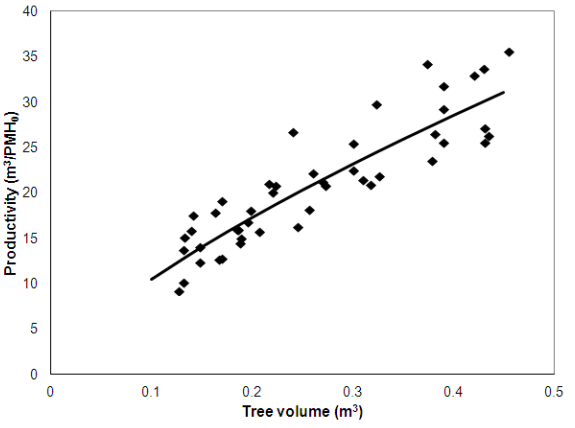
$$\text{Productivity} = \frac{\text{tree count} * \text{mean tree vol}(m^3)}{\text{Duration of count (hours)}}$$

Data collection – What about the 'Hawthorne effect'?

- 'Hawthorne effect' = change in the performance of a person being observed
- Mitigated in current study by:
  - Longer observation periods (>1.5 hrs where possible)
  - Observation from behind the harvester

Source: http://d.lib.ncsu.edu/collections/catalog/0006398

General harvester productivity model



Productivity = $55.36458 * TreeVol^{0.725383}$

Mean bias = -0.03
RMSE = 3.0
R^2_{corr} = 0.79

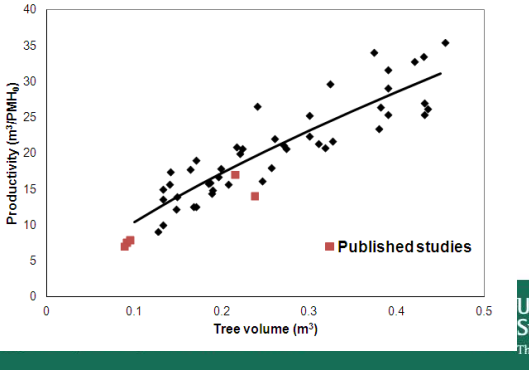
- Relationship close to linear

Examination of the model

- How does it compare with published models?
- What is the upper limit of the model?
- Was there any effect of:
  - Season?
  - Operator experience?

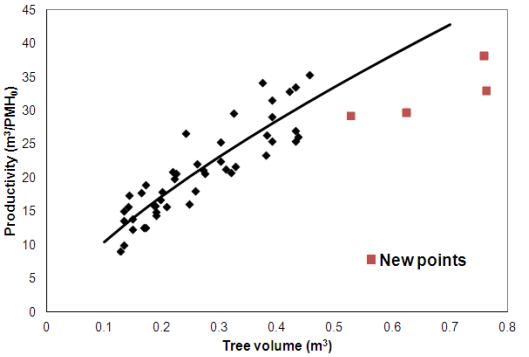
Comparison with published studies

- Very few comparable published studies
- Mostly at low end of mean tree volumes
- Generally agree with the model from this study



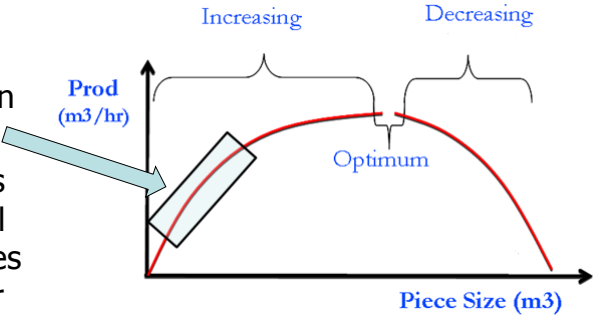
Upper limit of model?

- Few Australian *E. globulus* plantations with mean tree volume >0.5m^3
- *But!* Recent observations suggest curve does not continue on the same trajectory for larger mean tree sizes



Visser et al.'s 'Sweet spot'

- Harvesters in study operating well within their capabilities
- Suggests harvesters were chosen to deal with the largest trees they may encounter rather than the majority



Source: Visser, R., Spinelli, R., Saathof, J. and Fairbrother, S. (2009) Finding the 'sweet-spot' of mechanised felling machines. Proceedings of USA 32nd Annual Meeting of the Council on Forest Engineering (COFE), June 15-18, 2009, Kings Beach, CA, p. 10.

Effect of season

- Study sites had pronounced seasonal rainfall differences ("Mediterranean climate")
- Eucalypt debarking appears to be considerably easier when trees are not water-stressed

Source: www.deere.com

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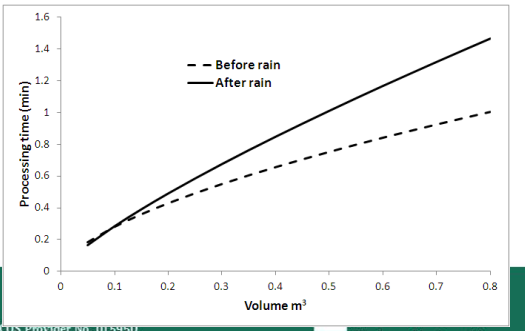
Effect of season

- Results of a harvester productivity study when 50mm of rain fell between measuring two plots after a dry period
  - Significant reduction in processing time after rain, particularly for larger trees, due to easier debarking



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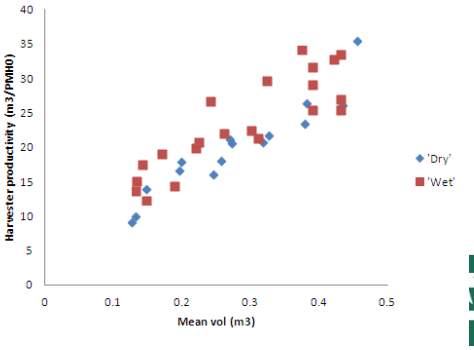
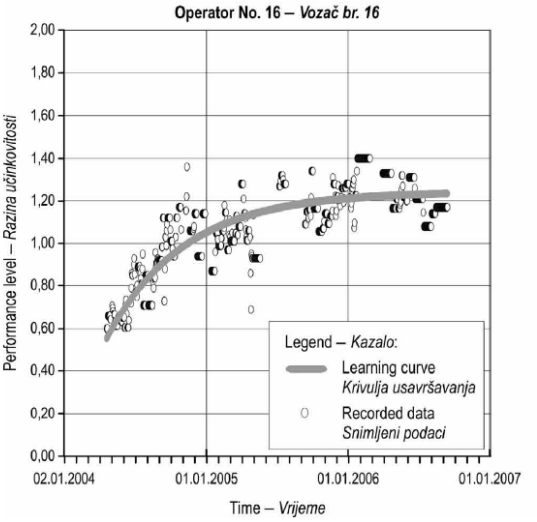
Effect of season

- Each T&P count point was allocated to 'Wet' or 'Dry' based on rainfall prior to the measurement date
- Some effect was noted but more data needs to be collected



Effect of operator experience

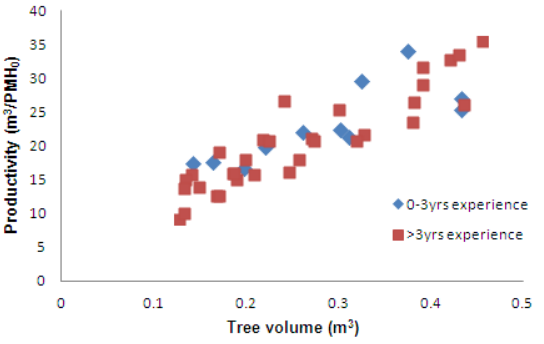
- Operator experience is known to be a factor in harvester productivity



Source: Purfürst, F.T. Learning curves of harvester operators. *Croat. J. For. Eng.* ***2010, 31, 89–97.***

Effect of operator experience

- Operator experience was divided into <=3 years and >3 years
- No clear effect, however most operators had >3 years experience



Conclusions

- Time and piece counts can be used to develop a general harvester productivity model
- Operator experience had no effect on the model
- Possible seasonal effect on productivity
- More data is required to:
  - Check for seasonal effects
  - Revise model for larger mean tree sizes

Acknowledgements

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Any questions?