Economic analysis of a Eucalyptus globulus stocking and harvesting trial in Western Australia

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Overview

- Background & objectives
- Stocking and harvesting trial
- Yield and harvest productivity modelling
- Economic analysis
- Results
- Summary

Background

- Australia has over 1,000,000 ha of Eucalyptus plantations
- Established since 1990, primarily as a source of pulpwood & woodchips
- Plantations planted at a stocking density of approximately 1000 – 1250 stems per ha & a target rotation length of 10 years

Background

- Several studies have showed that increasing initial stocking density decreases tree volume and diameter
- Manipulation of plantation stocking density on individual tree size can affect final harvest costs and productivity -> tree size is a major driver of harvesting costs and productivity
- However, harvest costs impacts need to be considered in the context of the total costs and returns for a rotation

Objectives

- Quantify the effect of stocking density on standing tree traits including DBHOB, tree height, tree volume, and tree form traits (branchiness and forks)
- Quantify the effect of stocking density on harvesting traits including machine hourly productivity and cost
- Conduct an economic analysis and determine optimal rotation ages and LEV of different stocking densities
- Conduct a sensitivity analysis to determine the factors with the greatest incidence on LEV

Stocking and harvesting trial

- 18 (35x30 m) plots
- 4 treatments
- Thinning to waste at age 3.2 years

Stocking and harvesting trial

- Harvester: CAT 322L tracked excavator base with an 20-inch Waratah HTH620 head
- Experienced operator
- Product specification focused on the production of 5.2 m logs

- Felling across a 3 row face
- Cycle and elemental times: digital video and manual recordings

Yield and harvest productivity modelling

- Trees were measured for DBHOB, tree height, and survival on 6 occasions during the trial period (age 3.2, 3.4, 4.3, 5.4, 7.6, & 9.5 years)
- The volume increment was used to developed a yield model which in turn was used to generate MAI and LEV curves from ages 5 to 12
- A general harvesting productivity model was developed including the following independent variables: “Stocking treatment”, “tree size”, “branchiness”, and “forking”

Economic analysis - LEV

$$LEV = \frac{\left[-E + \sum_{t=1}^{R-1} \frac{I_t}{(1+r)^t} + \frac{A\left[(1+r)^R - 1\right]}{r(1+r)^R} + \frac{P\,Y}{(1+r)^R} - \frac{H\;Y}{(1+r)^R} \right](1+r)^R}{(1+r)^R - 1}$$

Optimal rotation age that maximizes LEV calculated with Excel's solver

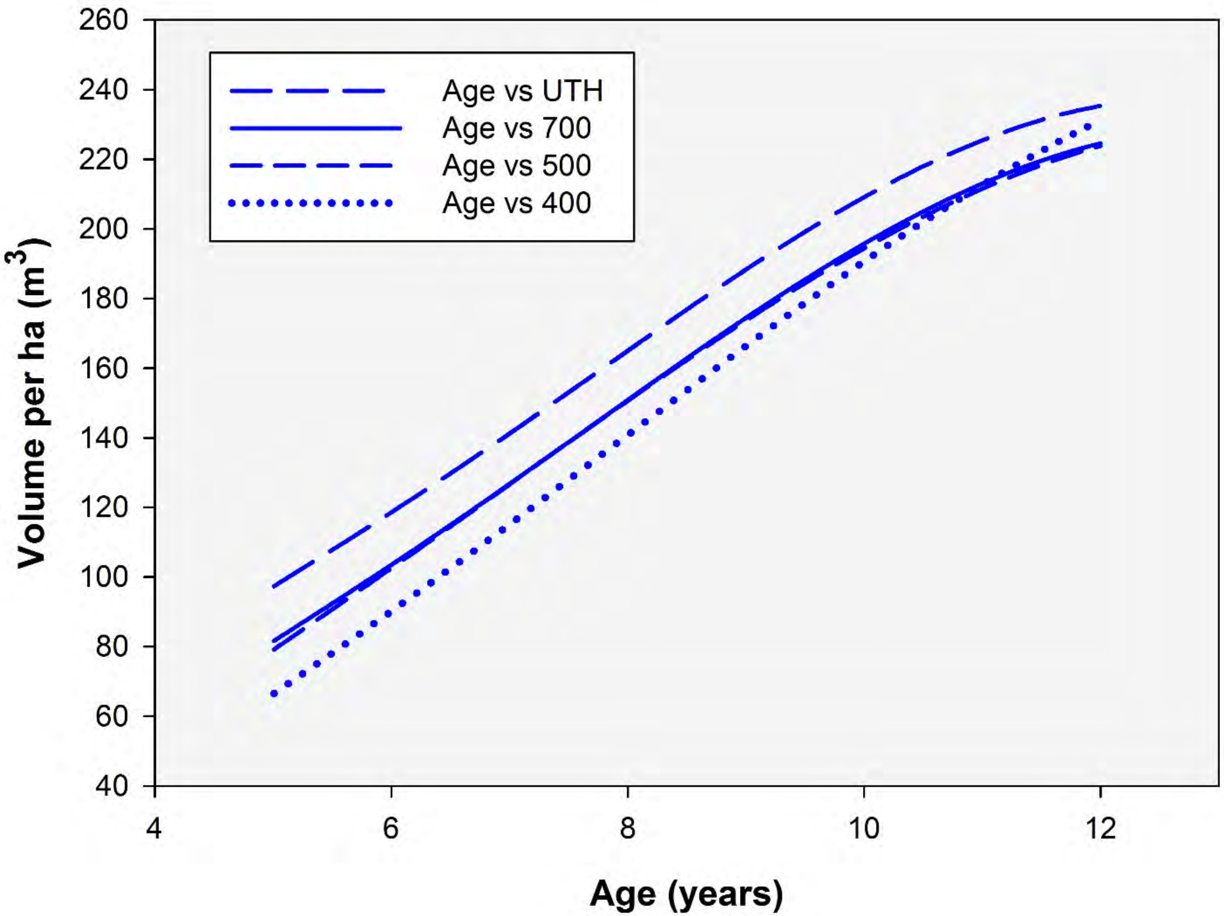
where,

LEV = Land Expectation Value per unit area
R = the length of a rotation (in years),
E = the stand establishment cost per unit area,
A = the annual land leasing cost per unit area
It = the thinning-to-waste cost per unit area occurring after plantation establishment and before the final harvest,
Y = the expected yield of pulplogs (m^3) per unit area at the final rotation,
P = the mill gate price of pulplogs per m^3,
H = the harvesting and transportation cost per m^3, and
r = the real interest rate.

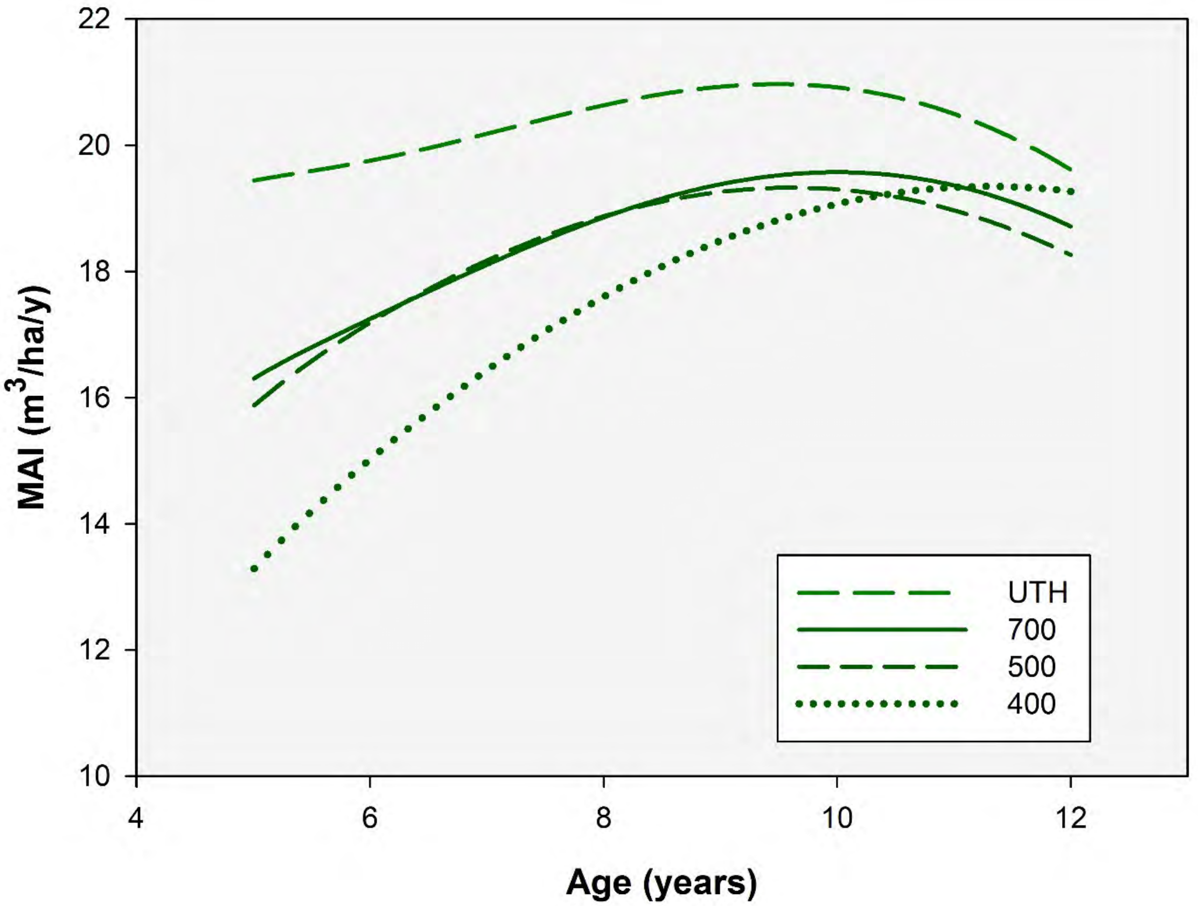
Results – Tree and stand factors at the time of harvest (age 9.5)

Tree and stand factors	Target stocking (trees/ha)			
	UTH	700	500	400
Number of treatment plots	3	3	6	6
Actual merchantable stocking (tph)	978	637	489	393
Mean tree diameter (DBHOB), mm	174	205	226	253
Mean tree height, m	20.0	21.4	22.2	23.7
Mean standing tree volume, m^3/tree	0.233	0.286	0.366	0.464
Stem form (Forking), % of trees				
Class 1	62	62	77	77
Class 2	38	38	23	23
Merchantable yield, tonnes/ha	194.6	179.9	178.1	180.2
Differential		-8%	-8%	-7%

Results - Growth curves



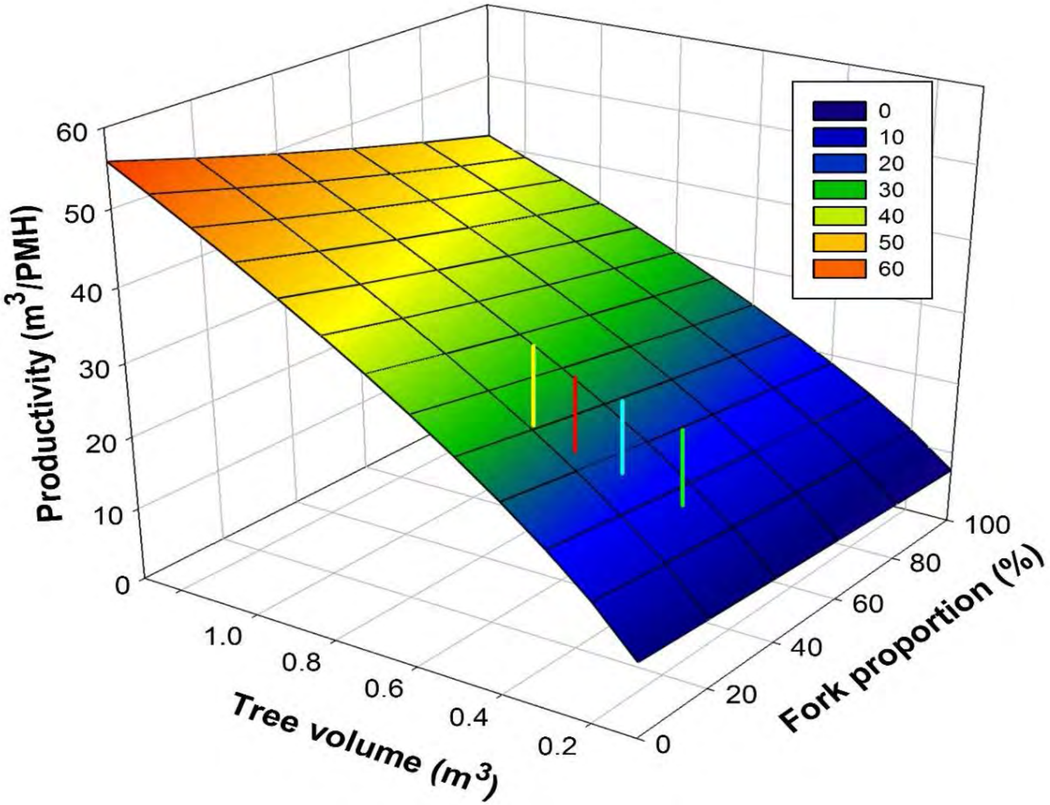
Results - MAI Curves



Results – Time study

	UTH		700		500		400	
Work Element	Mean time per cycle, sec.	% of cycle time	Mean time per cycle, sec.	% of cycle time	Mean time per cycle, sec.	% of cycle time	Mean time per cycle, sec.	% of cycle time
Felling	16.1	17.6	14.4	16.9	14.3	14.8	15.7	15.8
Processing	71.3	78.1	66.5	78.2	77.3	79.9	77.8	78.2
Brushing or cleaning	0.8	0.8	0.12	0.1	0.26	0.3	0.20	0.2
Moving	3.0	3.3	3.8	4.5	4.7	4.9	5.6	5.6
Travelling	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total	**91.4**	**100.0**	**85.0**	**100.0**	**96.8**	**100.0**	**99.5**	**100.0**

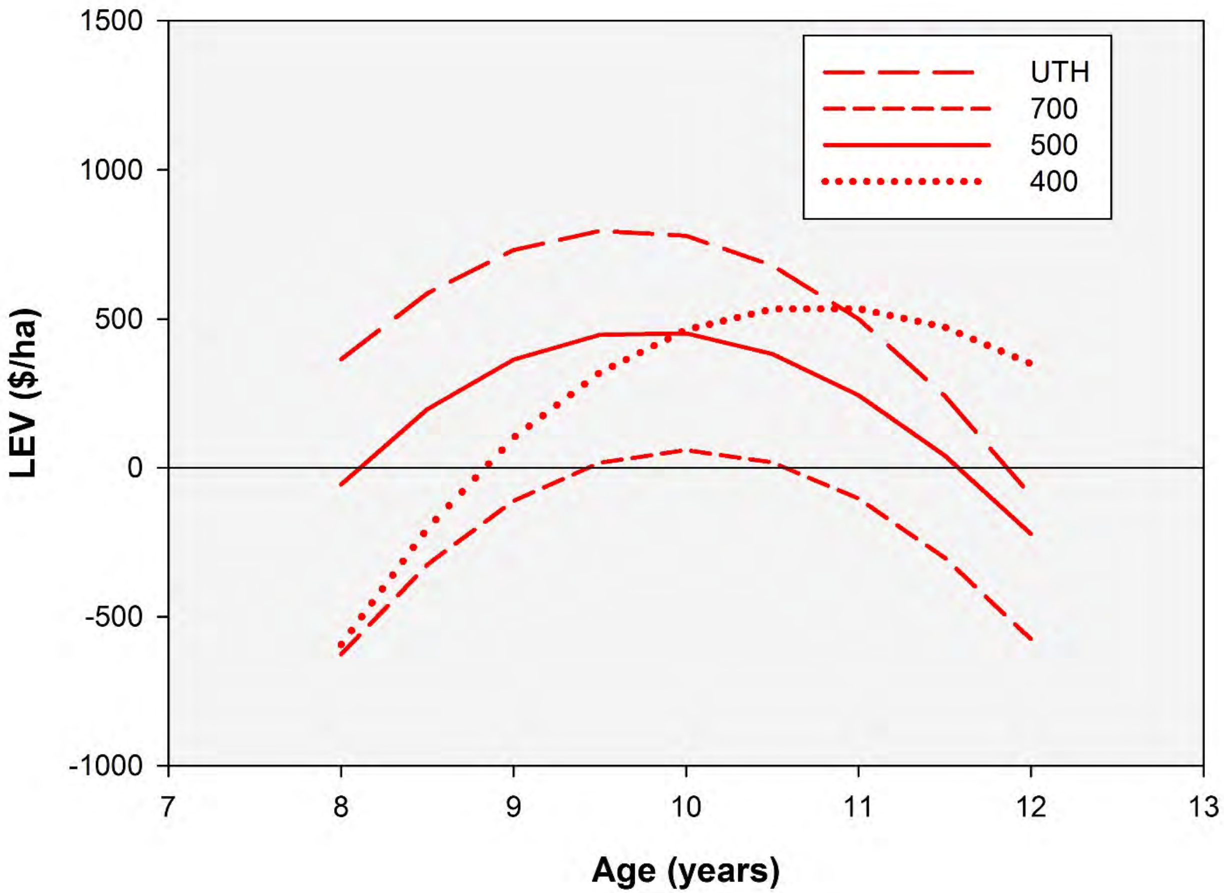
Results - Harvest productivity model



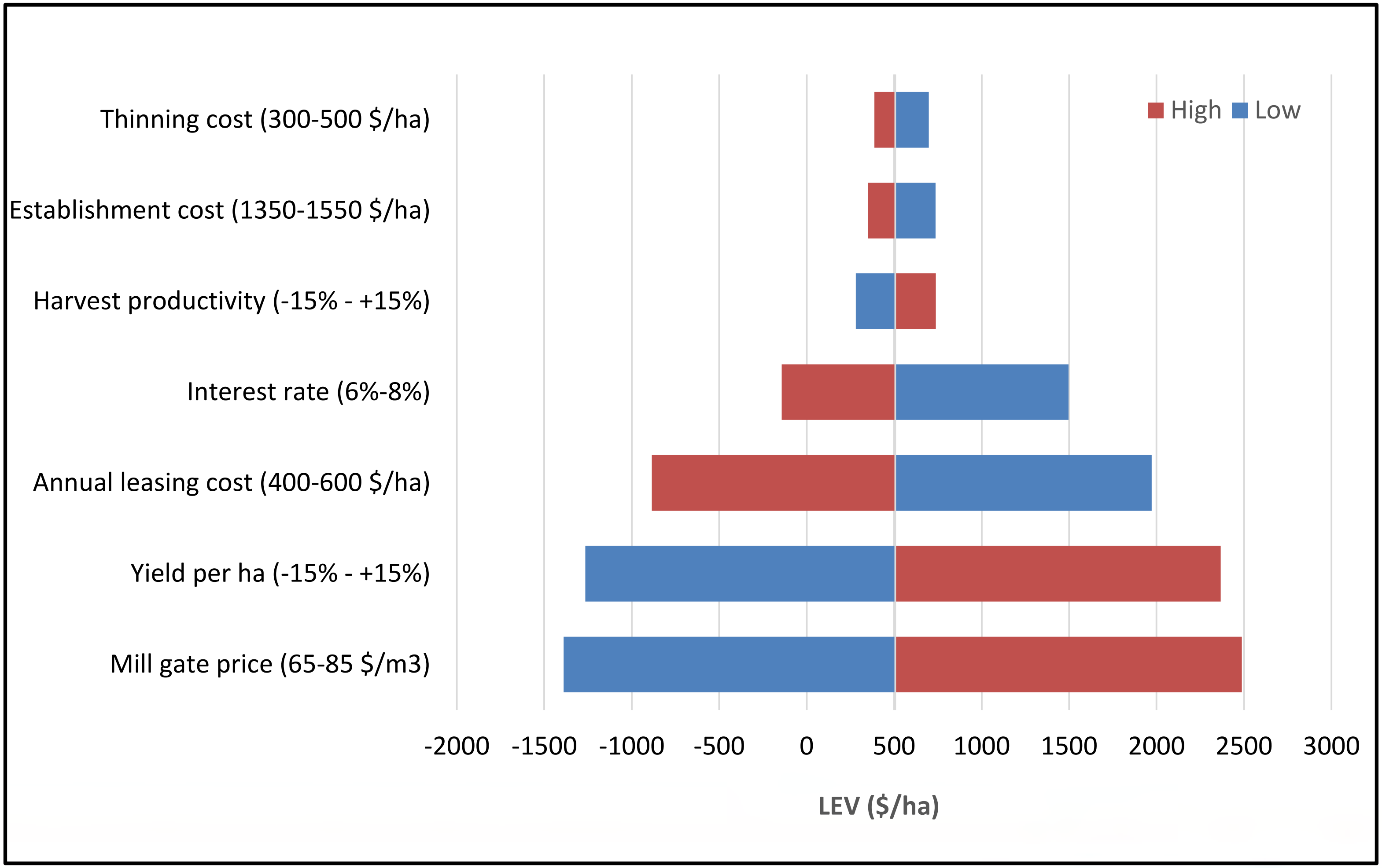
- R2 = 0.85
- Productivities:
  - 400 (25.9 m3/PMH)
  - 500 (22.8 m3/PMH)
  - 700 (18.3 m3/PMH)
  - UTH (14.5 m3/PMH)

ln(Productivity) = 3.848 - 0.301*Forking + 0.668*ln(TreeVolume)

Results - LEV curves



Results - Sensitivity analysis on LEV



Summary

- Plantation stocking density can affect final harvest productivity and cost
- The economic analysis showed that at their optimal rotation age, all the stocking treatments resulted in a lower LEV and net financial loss over the full rotation when compared to the unthinned control (UTH) stocking treatment
- Positive impacts on individual tree growth and form and associated reductions in harvesting costs did not compensate for overall losses in per ha yield

Thank you!