



Implications of mechanised silviculture on tree spacing and productivity in pulp plantations and implications to harvesting

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- Planting density & Rotation age to reach ave target tree size for
mechanised harvesting
- Inter-row width for mechanised silviculture
- Effect of rectangular planting pattern on volume production
- Within context of Eucalypt pulpwood

Objectives of Pulpwood Growers

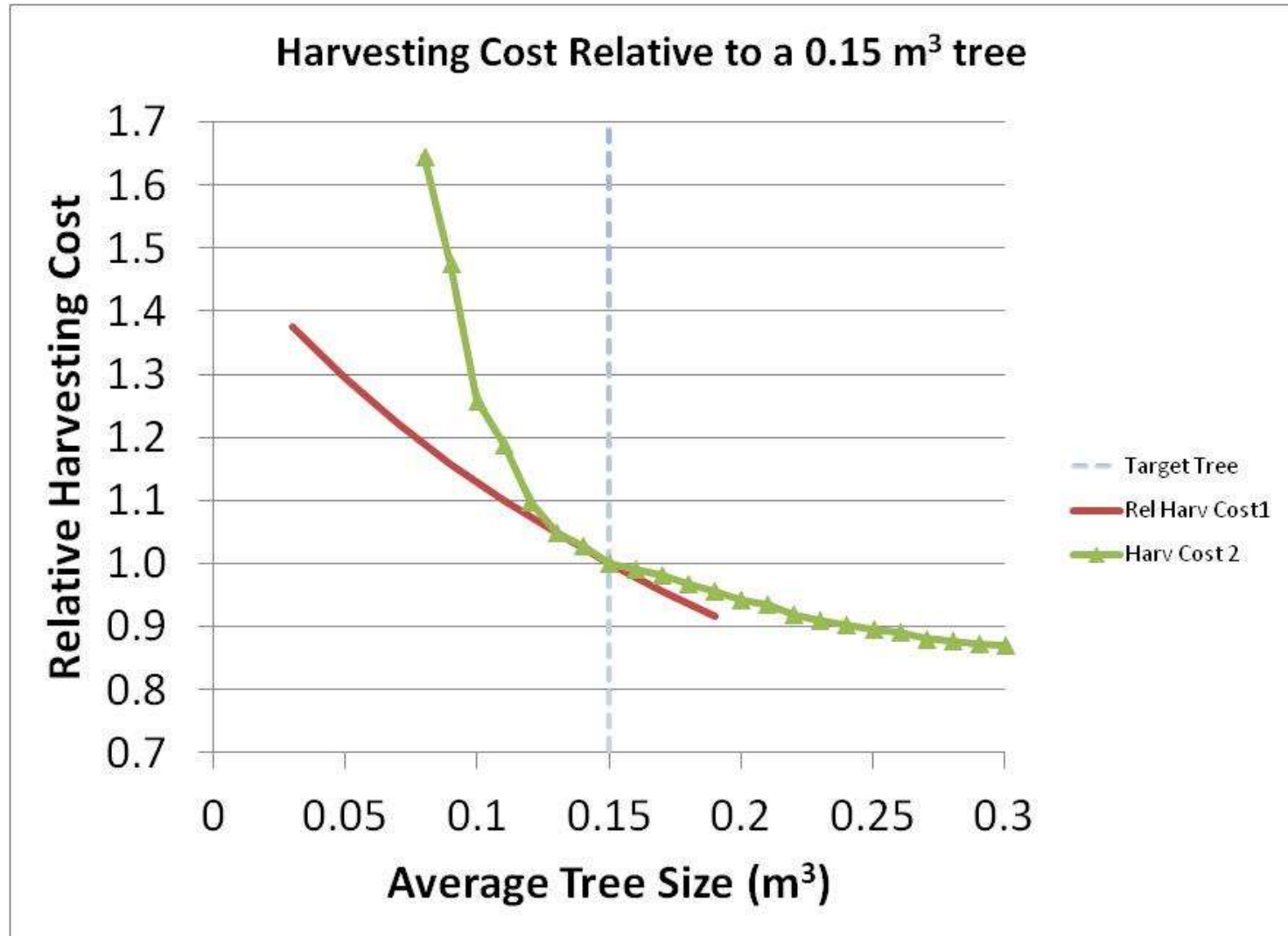


- Maximize volume production on our land base
- Minimize production costs

Harvesting Costs



Tree size is a huge cost driver in mechanised harvesting.



Results from spacing trials



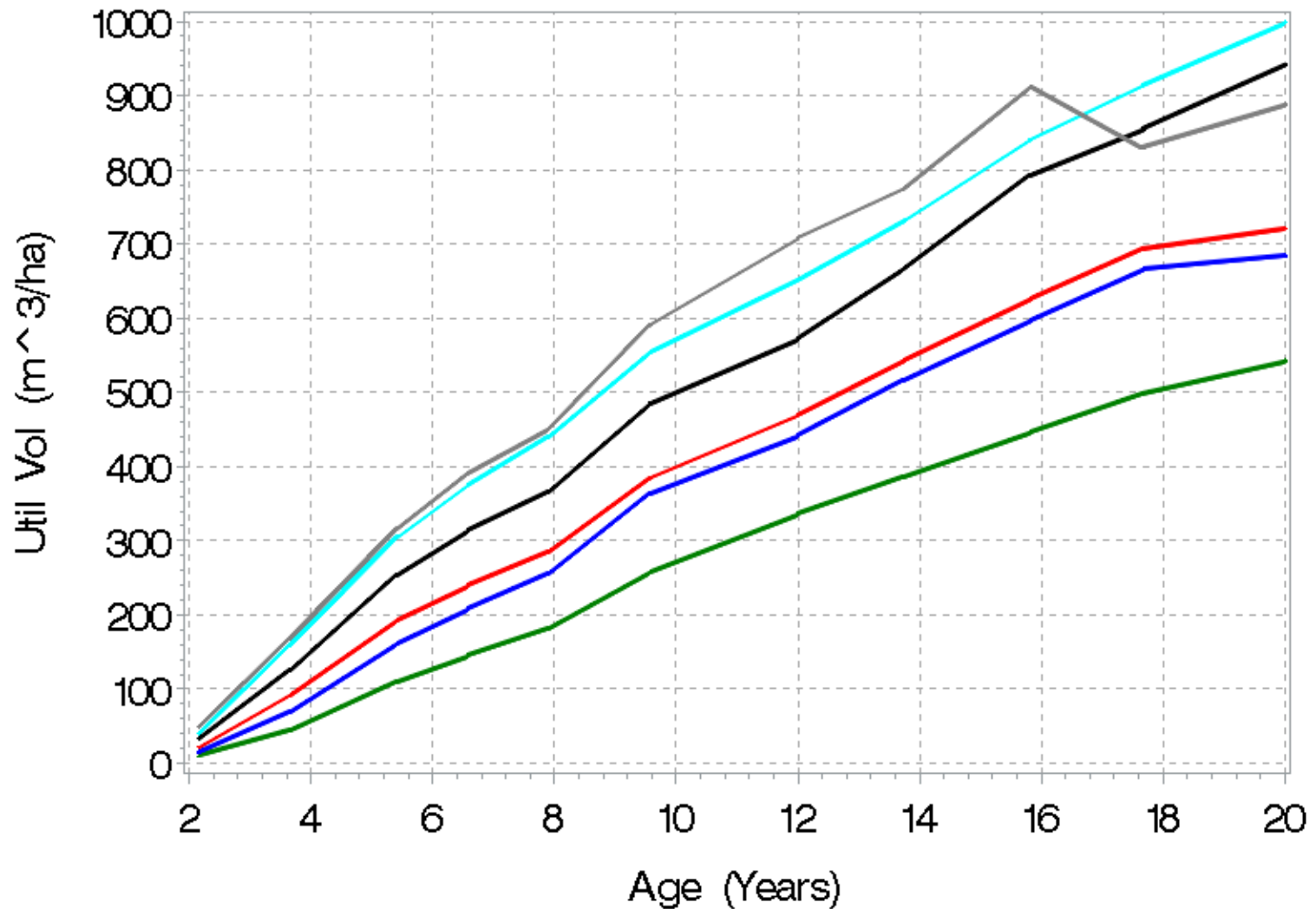
- Spacing trials illustrate stand-level responses to Planting density
- Informs our understanding of stand dynamics
- Seedlings and Clones may respond differently to planting density

Seedling	Clone
<i>E.grandis</i>	<i>Egxu</i>

Volume/ha production over time: *E.grandis* seedlings



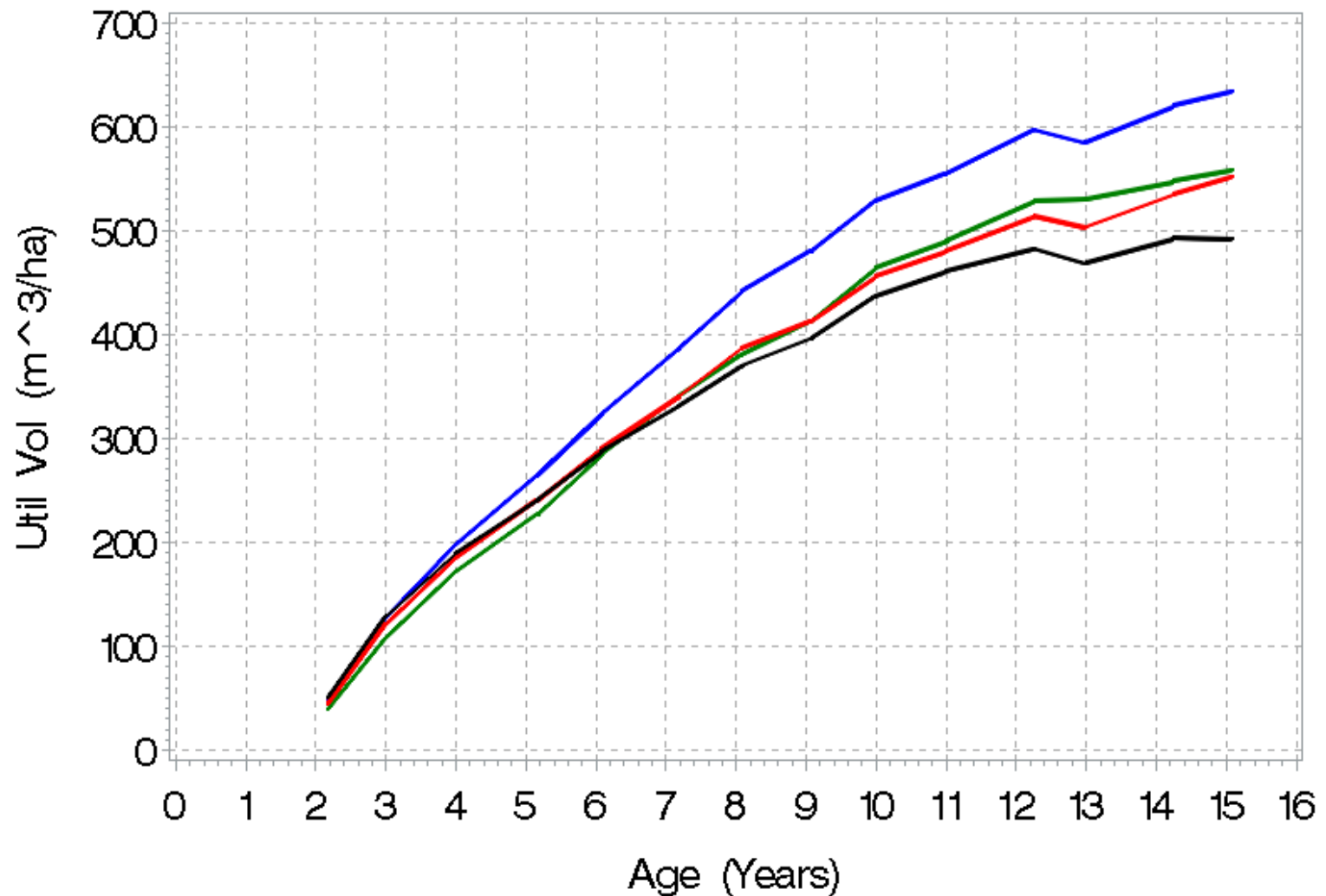
View Vm: Green= 245, Blue= 403, Red= 665, Black= 1097, Cyan= 1808, Grey= 2965



Volume/ha production over time: Egxu clones



View Vm: Green= 1111, Blue= 1389, Red= 1667, Black= 1852

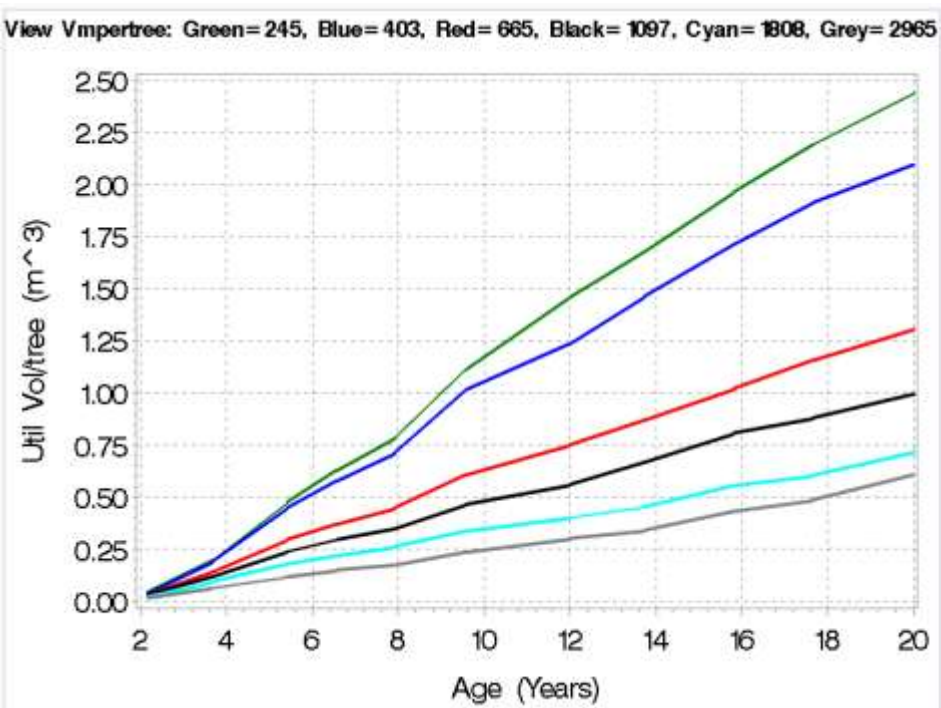


Individual tree Volume

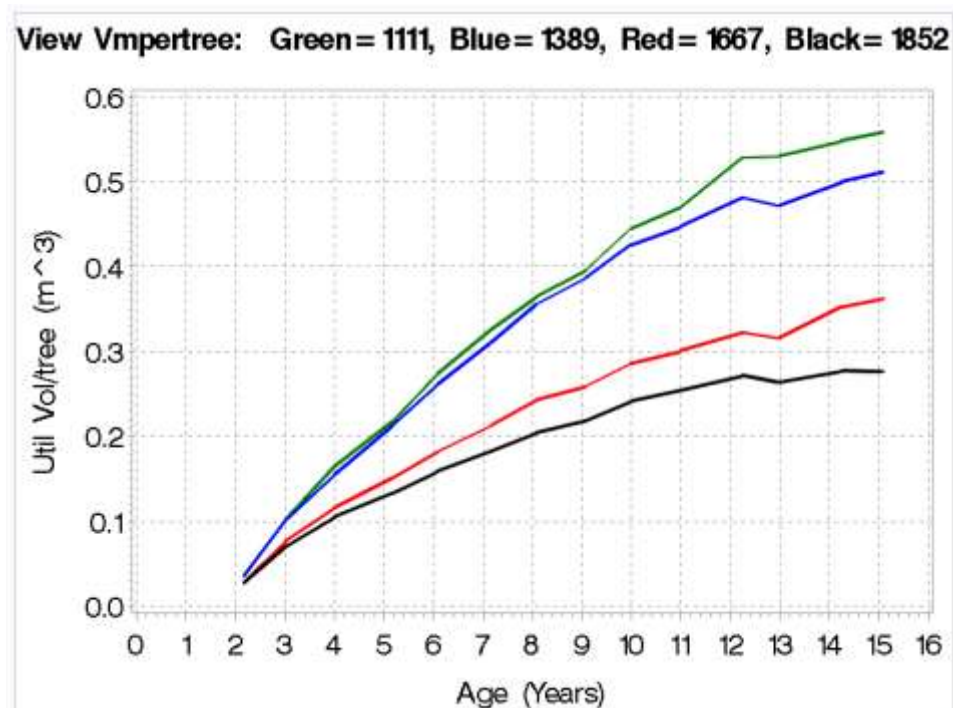


Planting density gives great control over tree size

Egrandis seedlings



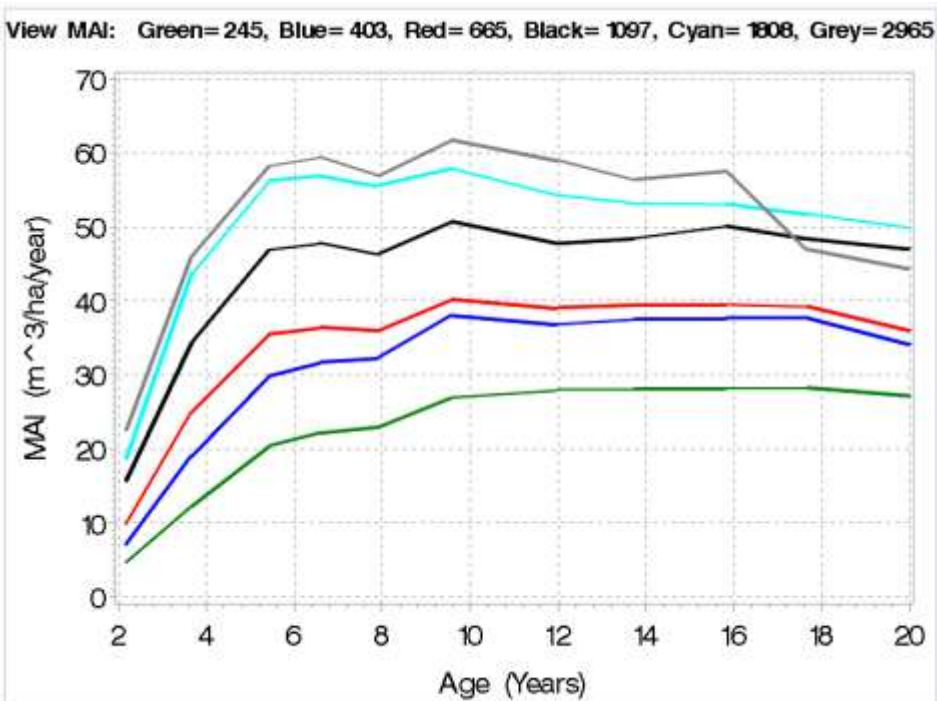
Egxu clones



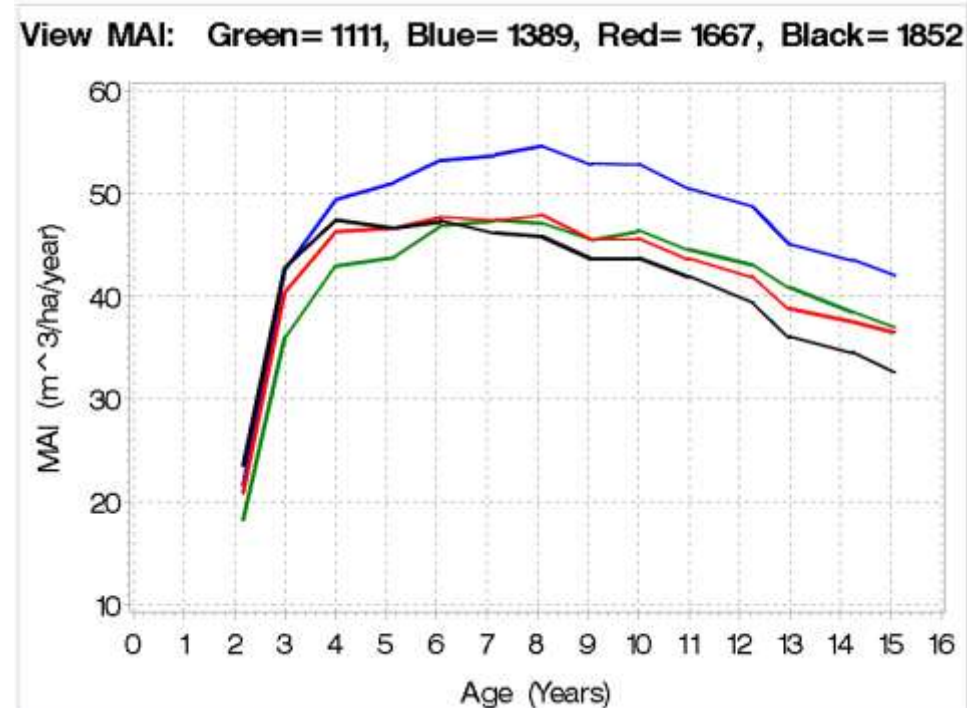
MAI culmination age



Egrandis seedlings



Egxu clones



Results from spacing trials



- In terms of volume/ha:
 - higher planting densities produce maximum volume until lower planting densities catch up and cross-over
- We have great control over tree size with planting density
- But never disregard:
 - the effect of erratic rainfall cycles,
 - pests and disease.
- Seedlings and clones may behave differently:
 - over planting density and time

Choice of planting density & rotation age



- For a choice of planting density & rotation age we also require a view of stand-level economics
- Local knowledge on typical survival % at rotation age
- When Harvesting cost is linked to tree size, economics lean towards:
 - bigger tree sizes and
 - thus a lower planting density.

Forest Ecology and Management, 29 (1989) 245-266
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

Initial Spacing, Stand Density and Thinning in Eucalypt Plantations¹

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- *'In general tree rows should not be wider than 3m, and spacings within rows should be closer on better sites, when optimization of total volume is the main objective.'*
- Basically 1667 on good sites, and no less than 1333 on poorer sites
- If tree lines are straight, 3m row widths should be adequate to allow mechanical weeding and access for harvesting equipment.

Requirements of mechanised silviculture



- Mechanised silviculture requires:
 - a minimum inter-row width to allow access for machinery
 - precision of rows
 - low stump heights
- Is the 3m row width still adequate?
- If not, can we push it to 3.5m or 4m?
- What is the effect of increased rectangularity on volume production and other factors like weed control?

$$\text{Rectangularity} = \frac{\text{Inter - row distance}}{\text{Inter - plant distance}}$$

Planting density	Space/ tree (m ²)	Inter-row (m)	Inter-plant (m)	Rectangularity
1667	6.00	3.0	2.00	1.5
1667	6.00	3.5	1.71	2.0
1667	6.00	4.0	1.50	2.7
1667	6.00	4.5	1.33	3.4
1667	6.00	5.0	1.20	4.2

$$\text{Rectangularity} = \frac{\text{Inter - row distance}}{\text{Inter - plant distance}}$$

Planting density	Space/ tree (m ²)	Inter-row (m)	Inter-plant (m)	Rectangularity
1389	7.20	3.0	2.50	1.3
1389	7.20	3.5	2.06	1.7
1389	7.20	4.0	1.80	2.2
1389	7.20	4.5	1.60	2.8
1389	7.20	5.0	1.44	3.5

Results from Rectangular spacing trials



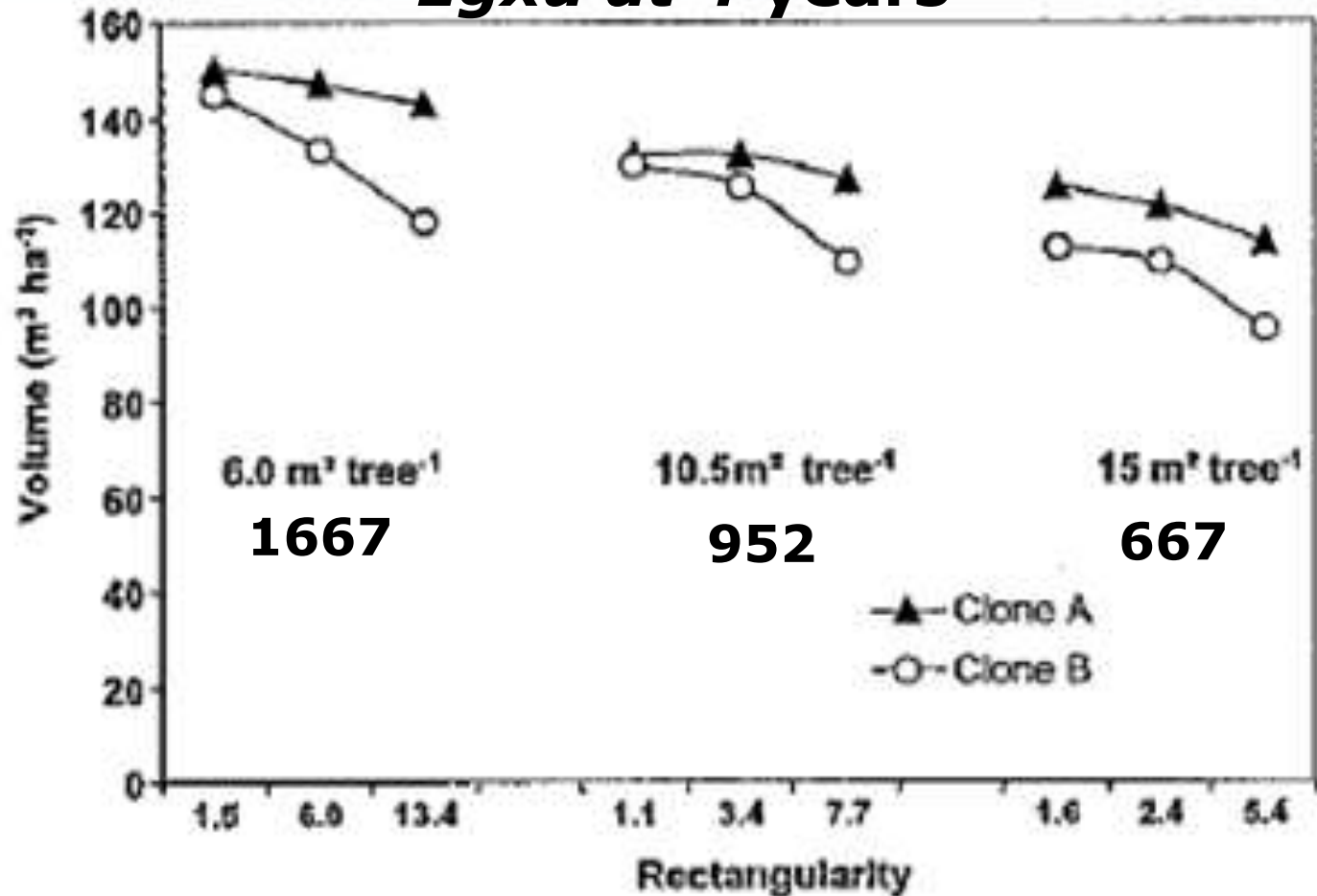
- Brazil:
 - *Egxu* trial at age = 4
- SAFRI:
 - *E.grandis* Nelder 1b trial at Frankfort, Sabie, age 6
- ICFR:
 - *E.grandis* at Greenhill, Richmond, at age 2
 - *Egxu* at Flatcrown, Zululand, at age 2

Results from Sao Paulo State, Brazil

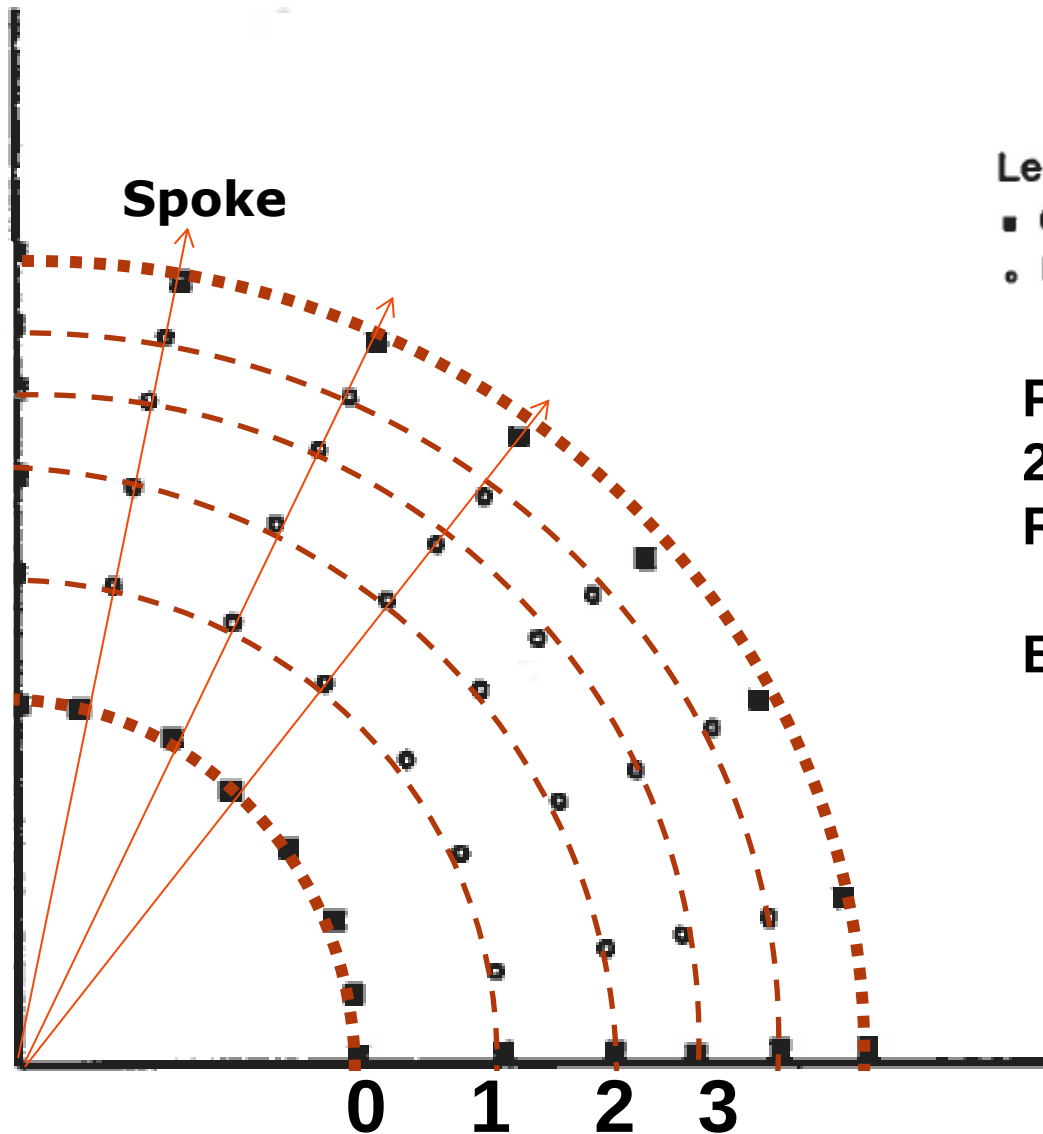


J.L.M. Gonçalves et al. / Forest Ecology and Management 193 (2004) 45–61

EgXu at 4 years



Nelder 1b in *E. grandis* at Frankfurt



Nelder 1b

Legend:

- Guard rows
- Experimental plants

PSPH=1333

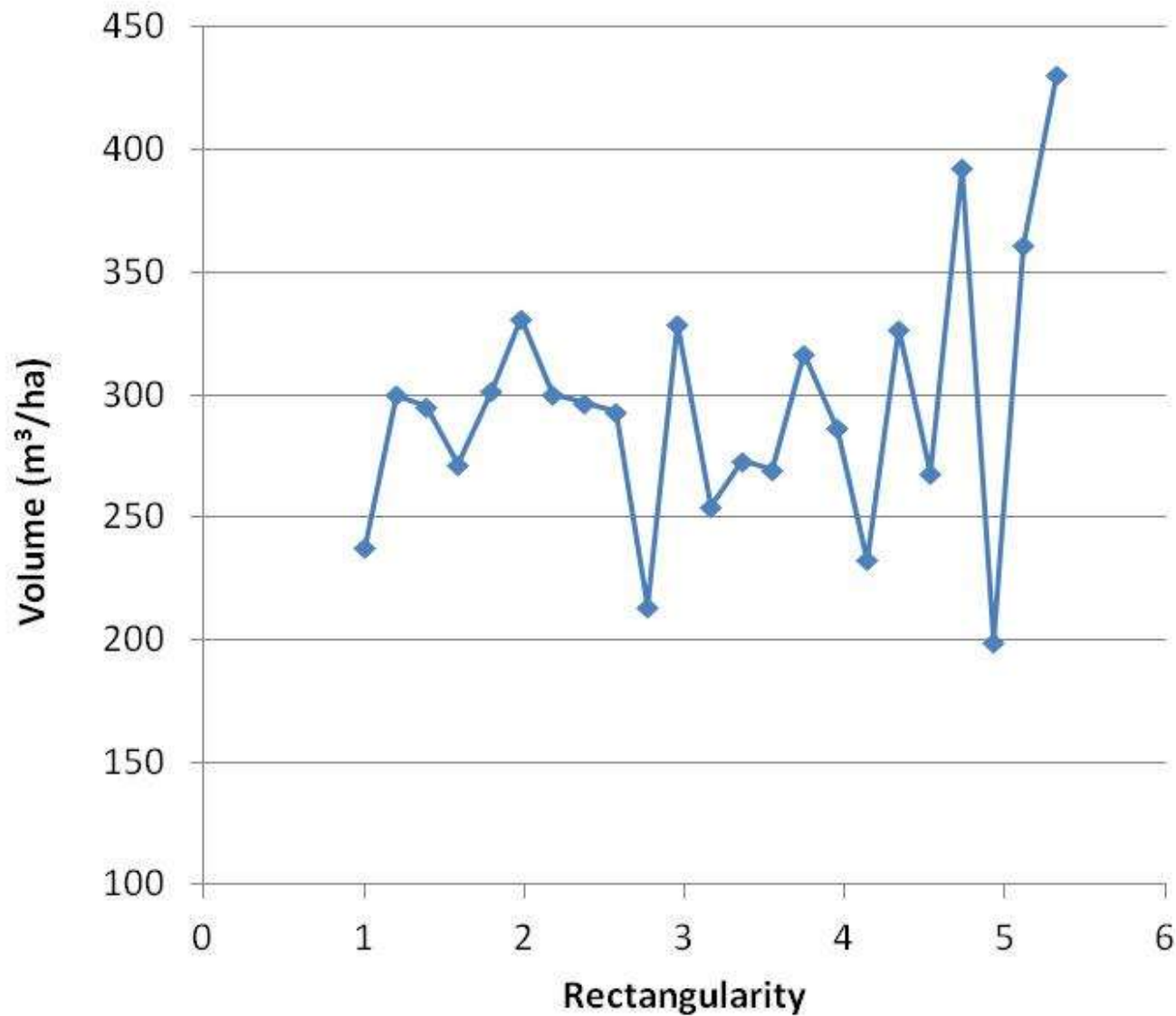
23 treatments with
Rectangularity from: 1 – 5.32

Bredenkamp, 1982

Results from the Nelder 1b in *E.grandis*, age 6



PSPH=1333



Rectangular spacing trial Greenhill



Planting densities

1000 – 1350 – 1700

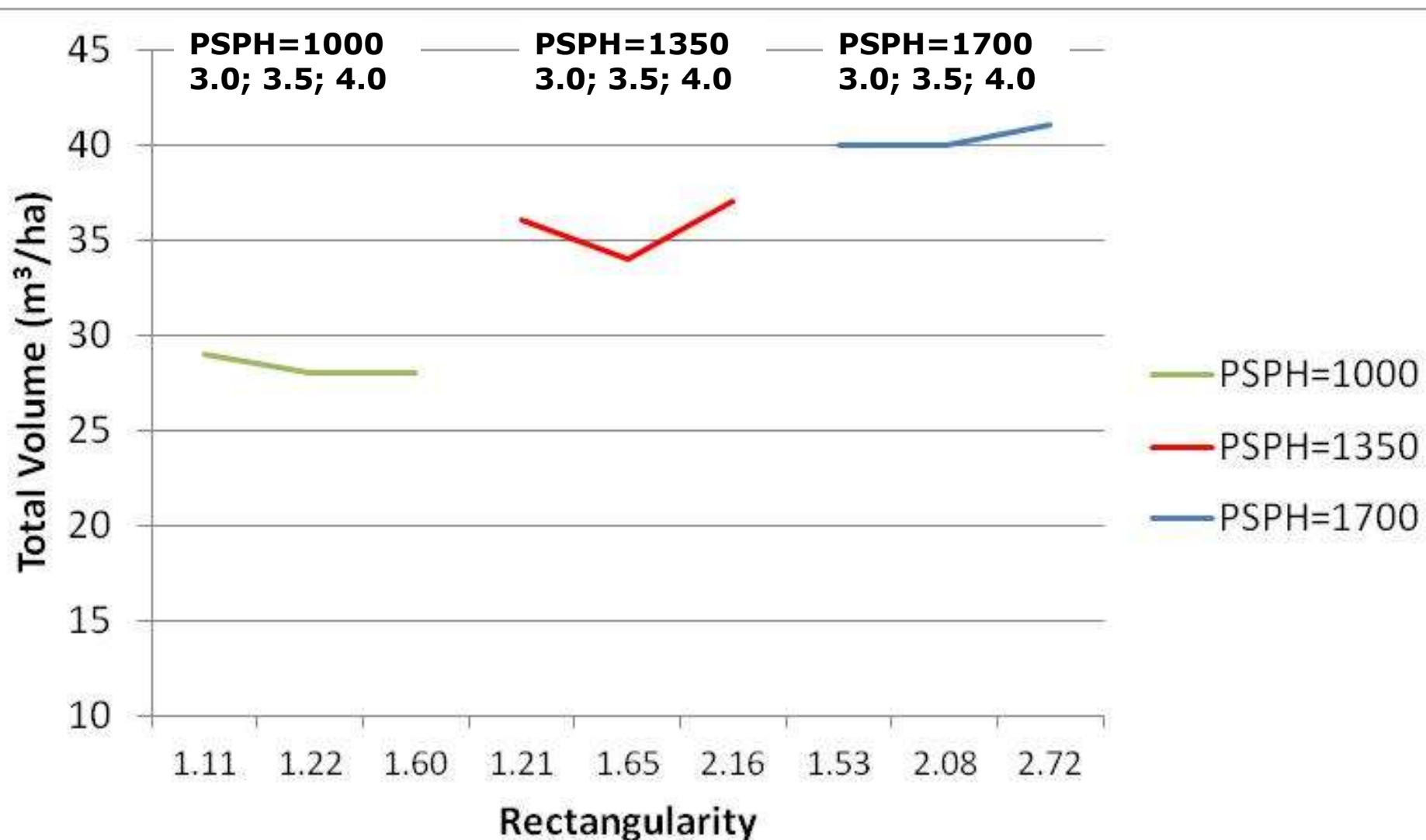
Rectangular planting pattern

3m, 3.5m, 4.0m

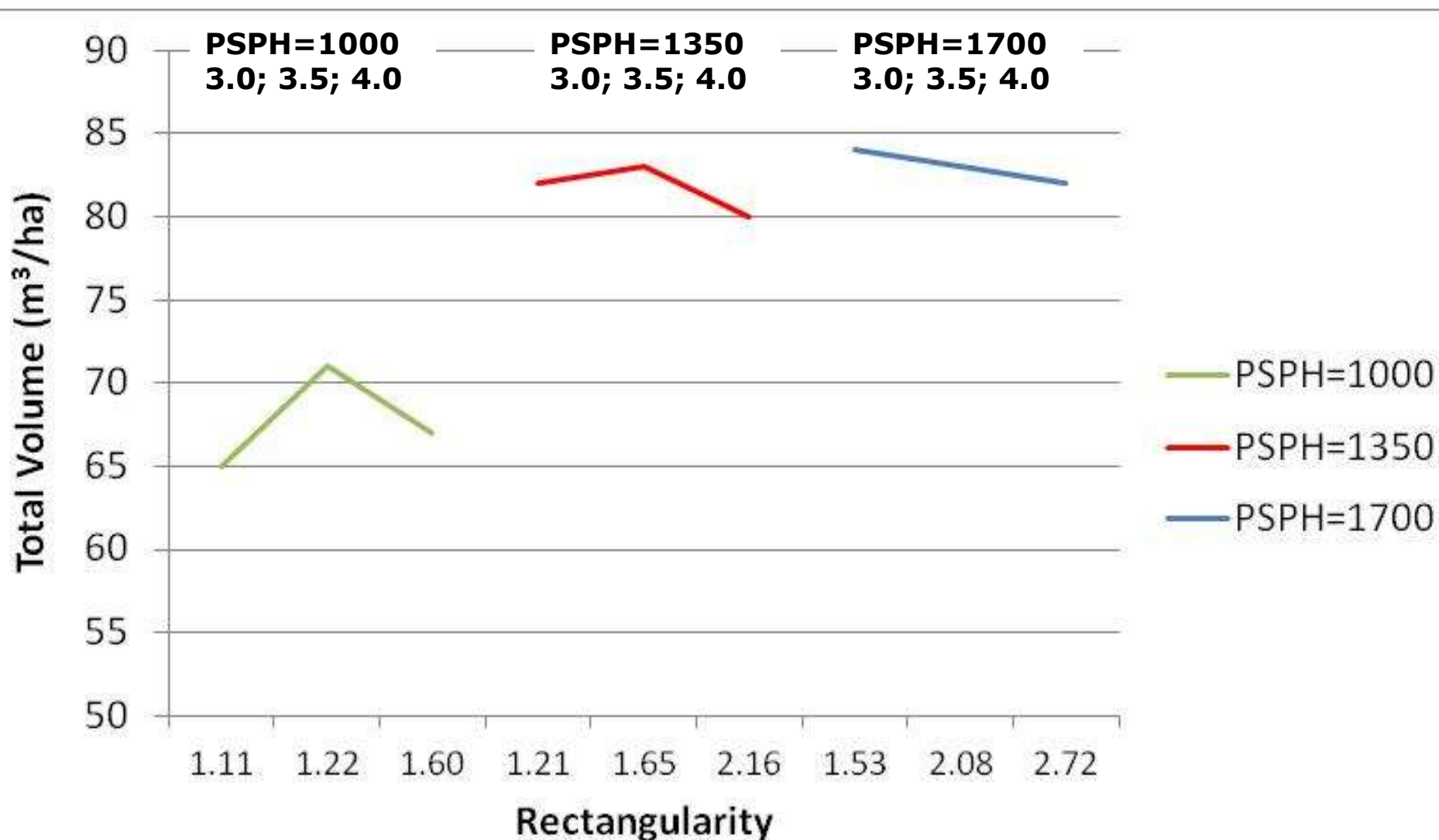
Species



Results from Greenhill, *E.grandis* at 2 years



Results from Flatcrown, Egxu at 2 years



Examples at 9 x 1m row width - Vietnam



Examples of 4 x 1.5m row width: Highlands



Conclusions



- Harvesting machines require bigger tree size for lower costs
 - Lower planting densities and/or
 - Longer rotations
- Silvicultural machines require wider inter-rows for practical access
- Both might lead to changes in volume production
- Re-engineering of row-widths is going to be very costly

Recommendations



- Keep developing our understanding to find optimums between Planting density, Rotation Age, Machine size and choice
- Follow the young ICFR trials to see if stronger trends develop into the effect of rectangular spacing on volume production
- Plant commercial blocks with different row-widths:
 - Comparative productivity work studies
 - Comparative costing
 - Determine practical effect on volume production

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