Testing native species as short-rotation woody crops in NSW

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NSW GOVERNMENT

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Objectives

- Screen woody native species for biomass production on a range of NSW sites
- ID species for short (3 – 4 year) harvest cycle
- Marginal sites or marginal parts of farms
- Native species for biodiversity benefits
- Biomass for bioenergy, biochar, metallurgical products, biochemicals, C-sequestration

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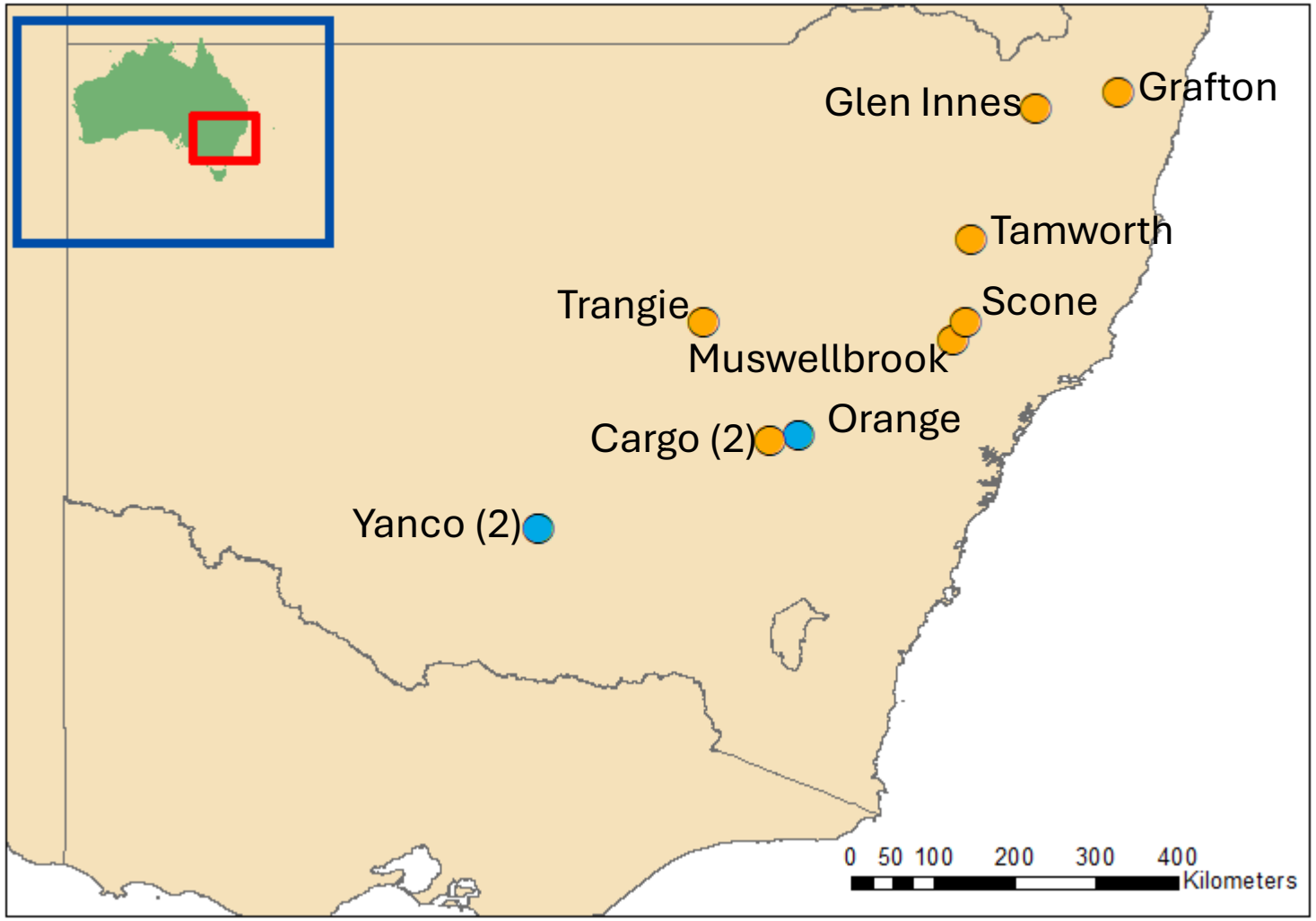
Trial sites



- 11 sites on farmland
- Areas chosen as areas of interest for biomass electricity generation
- Hunter region was one focus (energy hub)

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Species selection criteria

- Potential for rapid early growth
- Resistance to stressors including drought, frost
- Ability to coppice preferred
- Track record of performance preferred
- Australian native species preferred
- Tall trees (eucalypts, *Acacia*, *Casuarina*)
- Mallee eucalypts
- 15 species including 4 threatened spp.
  - 2 spp. previously untested anywhere

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Species-by-site allocations

Seed-lot	Provenance	Species	Glen Innes	Grafton (Grange SF)	Muswell-brook (Mach Energy)	Orange	Cargo ridge	Cargo saline	Scone	Tamworth	Trangie	Yanco 1	Yanco 2
15800	Moora, WA	*Acacia saligna*						x			x	x	
21475	various locations, ACT	*A. dealbata*	x	x	x	x			x	x			
16362	Singleton, NSW	*Casuarina glauca*					x	x			x		
21213	Kowen Seed Orchard	*Eucalyptus benthamii (V)*	x										
20561	Lake Albacutya, VIC	*E. camaldulensis*	x	x	x	x	x	x		x	x	x	x
21463	Singleton, NSW	*E. castrensis (E)*	x	x	x	x	x	x	x		x	x	
21153	Hamilton SSO	*E. cladocalyx*		x	x	x			x	x		x	x
20841	N of Canna, WA	*E. horistes*										x	
21304	Durikai, QLD	*E. infera (V)*	x	x	x	x		x	x	x	x	x	
20771	Coominglah SF, QLD	*E. moluccana*		x							x		
21111	SSO SW Victoria	*E. occidentalis*	x	x				x					
20680	West Wyalong, NSW	*E. polybractea*	x	x	x	x	x		x	x	x	x	x
21462	Pokolbin, NSW	*E. pumila (V)*		x	x				x				
21498	Tincurrin cultivated, WA	*E. spathulata*						x					
21464	Dubbo, NSW	*E. viridis*		x	x	x	x		x	x	x	x	x

E *endangered NSW Biodiversity Conservation ACT;* V *vulnerable EPBC*

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Bioenergy Crop Trial

Muswellbrook MACH Energy Australia

The **Muswellbrook** crop trial consists of 8 replicates with 8 species per replicate, planted across 3 ha of reddish brown fine sandy loam soil. It was planted in September 2020. The 2020 monthly rainfall for this area preceding planting was sporadic with some months above and some below average, but the annual rainfall was well above average to September and this provided great conditions for planting.

Trial layout

Species	Common name	Code
Eucalyptus camaldulensis	River red gum	2
Eucalyptus castrensis	Singleton mallee	3
Eucalyptus cladocalyx	Sugar gum	4
Eucalyptus infera	Durikai mallee	7
Eucalyptus polybractea	Blue-leaved mallee	9
Eucalyptus pumila	Pokolbin mallee	10
Eucalyptus viridis	Green mallee	12
Acacia dealbata	Silver wattle	5

E. pumila

E. cladocalyx

E. viridis

Timeline of events	2020									2021				2022		2023	
NB: will be updated as required	Jan	//	Mar	//	Jul	//	Sep	//	Nov	//	Mar	//	Sep	//	Sep	//	Sep
Ripping	■																
Non chemical weed control			■						■								
Chemical weed control					■												
Planting							■										
Irrigation							■										
6 months - measurements											■						
12 months - measurements													■				
24 months - measurements															■		
36 months - harvest crops																	■

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Trial design

- Trials statistically designed
- Large plots of 100 trees each species, with several “replicates” –thousands of trees per site
- Large plots allow biomass harvest sampling
- Replication allows statistical analysis and flexibility
- Fact sheets with trial designs are online

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Trial measures & analysis

1. Non-destructive measures

- Health
- Stem diameter
- Height and 2D width of tree
- Crown Volume Index (CVI)

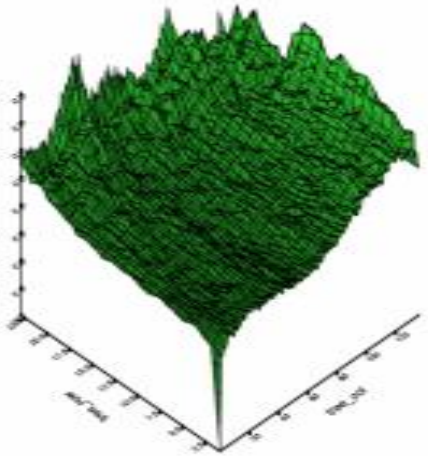
CVI is the volume of the box needed to contain the tree

2. Destructive harvest

- Removal of above-ground biomass
  - (trees re-shoot)

3. Analysis

- Spatial analysis of field data
- Correlation of destructive and non-destructive biomass measures



Spatial analysis corrects for site variation and neighbour effects

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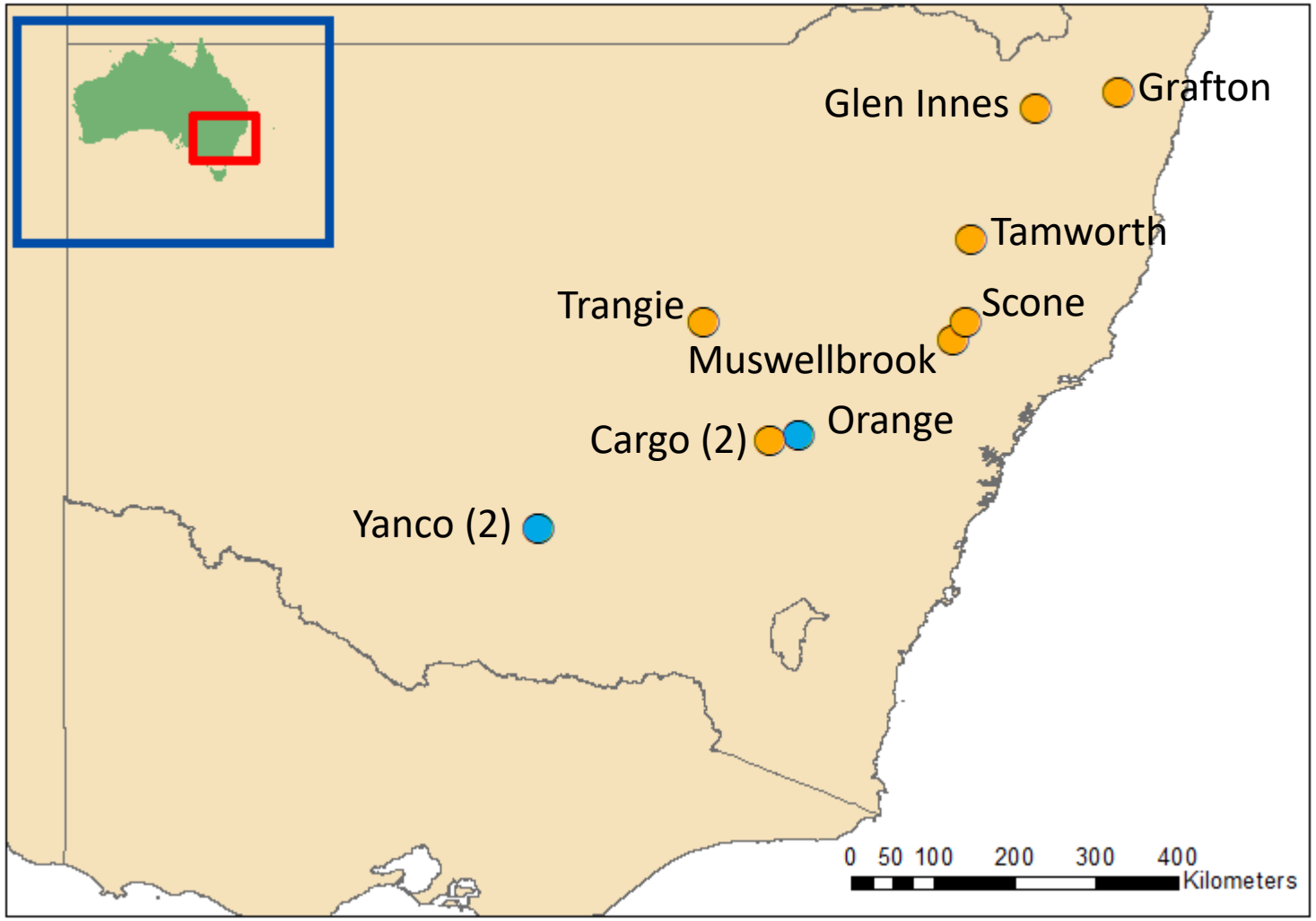
Site performance



Established 2019 Established 2020

Site	Survival @ 24 m	Survival @ 12 m	Status	Comment
Grafton	47%	N/A	Write-off	Weeds
Glen Innes	85%	30%	Poor survival, good info.	Cold! Some species have good potential
Tamworth	92%	86%	Good	
Scone	61%	40%	Establishment problems	Useful data from some plots
Trangie	96%	94%	Good	
M'brook	94%	93%	Good	
Orange	38%	N/A	Write-off	Drought, frost, waterlogging
Cargo ridge	96%	94%	Good	
Cargo discharge	67%	N/A	Poor	Too wet to assess
Yanco 1	44%	44%	Establishment problems	Drought. Useful data from survivors
Yanco 2	76%	77%	Good	

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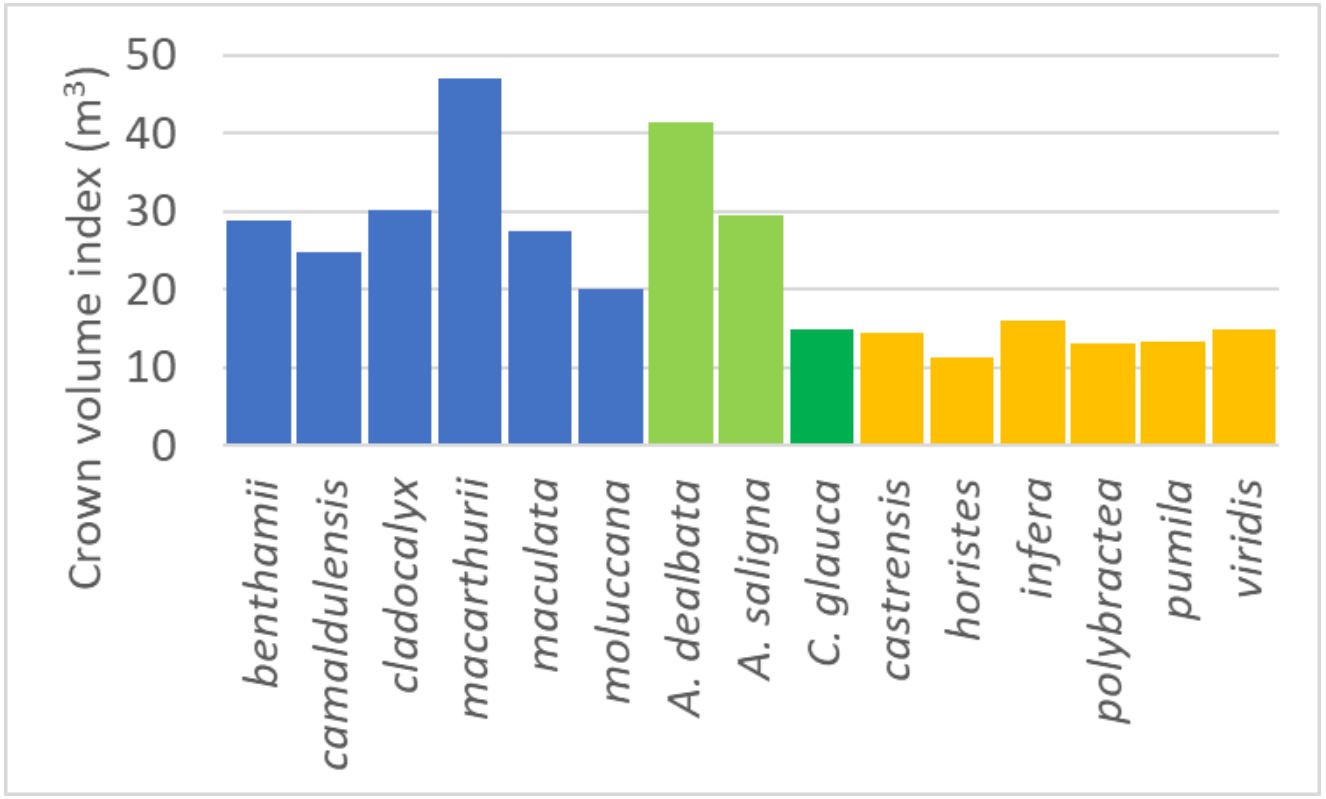
Which species did well?



36-month result (adjusted means across sites)

Summary of results

- *E. benthamii* did well on the cold Glen Innes site
- *E. cladocalyx* consistently good on many sites, *E. camal*. started well but faded
- The mallees started slowly and were out-grown
- The acacias did well on some sites
- Rainfall was v. below average prior to and immediately after establishment in 2019
- Very good seasons post-establishment in 2020

Higher rainfall

- Favoured the tall trees
- Disadvantaged mallee establishment due to weed competition

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Scone 24-month growth (CVI)

E. pumila (threatened mallee) (6.5 m^3)

E. polybractea (widely grown mallee) (2.6 m^3)

E. cladocalyx (tall tree) (19 m^3)

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Tamworth 36-month growth (CVI)

E. polybractea (widely grown mallee) (14.3 m^3)

E. infera (threatened mallee) (29.0 m^3)

E. camaldulensis (tall tree) (40.5 m^3)

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Biomass estimation – 36-month assessment

Whole tree on small load cell (Tamworth 36 months)

Whole plot chipped + en route to weigh bridge (Tamworth 36 months)

Assessments

- Sample of trees harvested individually, sectioned, weighed
- Samples re-weighed after oven drying
- Whole plots mechanically harvested, chipped and weighed
- Correlations between non-destructive measures and biomass

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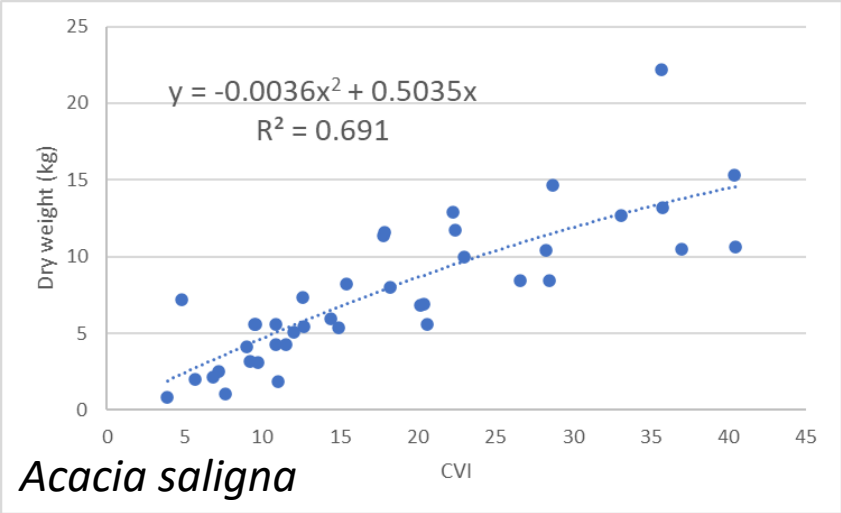
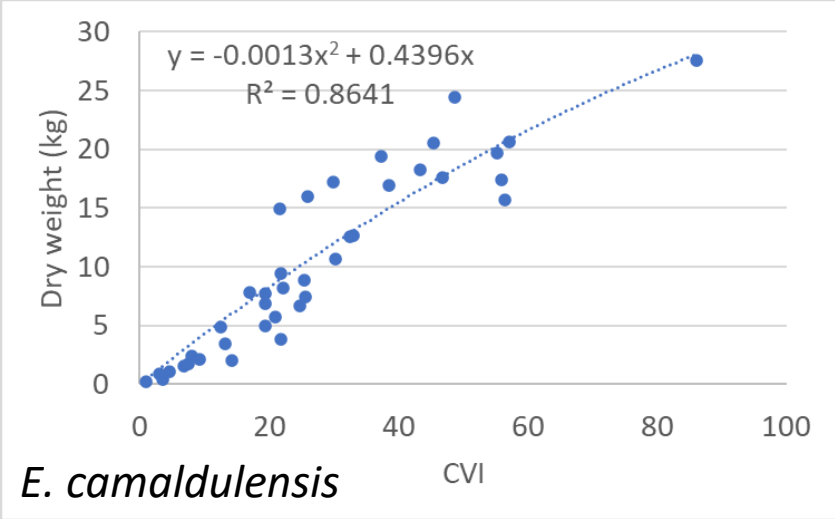
Biomass relationships

Individual crown volume index *versus* destructively harvested, dried and weighed biomass



Acacia saligna



E. camaldulensis

- Moderate - strong relationships between CVI and green or dry biomass
- CVI is rapid and non-destructive
- CVI can be used to estimate biomass productivity
- Whole-plot harvests for some spp./site combos

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Biomass estimates

Estimated standing biomass MAI (t/ha/year) based on CVI @36 months

	Cargo	Glen Innes	Muswellbrook	Tamworth	Trangie	Yanco 1	Yanco 2
Tall eucalypts							
benthamii		7.2					
camaldulensis	9.1		2.6	10.4	7.8		
cladocalyx			4.5	7.7		2.4	11.1
macarthurii				8.0			
maculata				5.2			
moluccana					4.4		
Acacia and casuarina							
A. dealbata			3.3	5.0			
A. saligna					7.6		
C. glauca	1.4				2.8		
Mallee eucalypts							
castrensis			2.6		4.1	3.5	
infera			1.5	5.1	5.2	4.7	
polybractea	1.4		1.1	3.2	2.0	3.4	6.0
pumila			3.1				
viridis	1.3		1.5	3.0	3.5	3.7	7.2

(These figures for dry biomass – green about double)

Caveats

- First rotation crops
  - 2nd rotation should be higher as roots already established
- Spp. trials not ideal for estimating biomass
  - Plot size = 450 m^2 – only OK
- Silviculture favoured tall trees
- Mallees not occupying site
  - Denser better: stocking trials underway
- Climate favoured tall trees
  - After 2019 rainfall has been good: mallees likely to do better in dry

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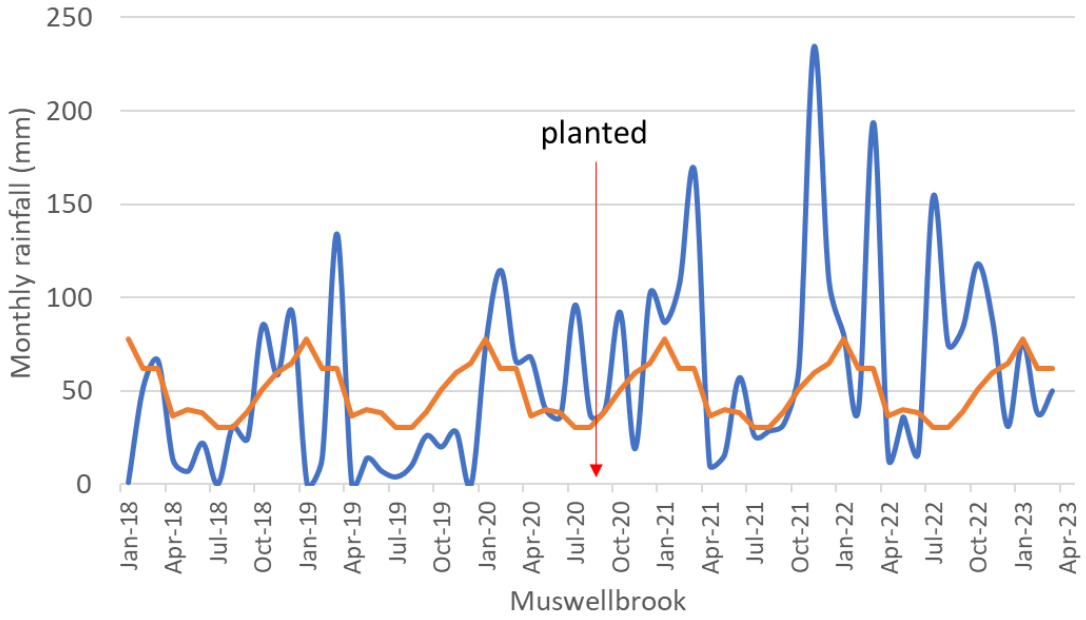
Climate (recent & future)

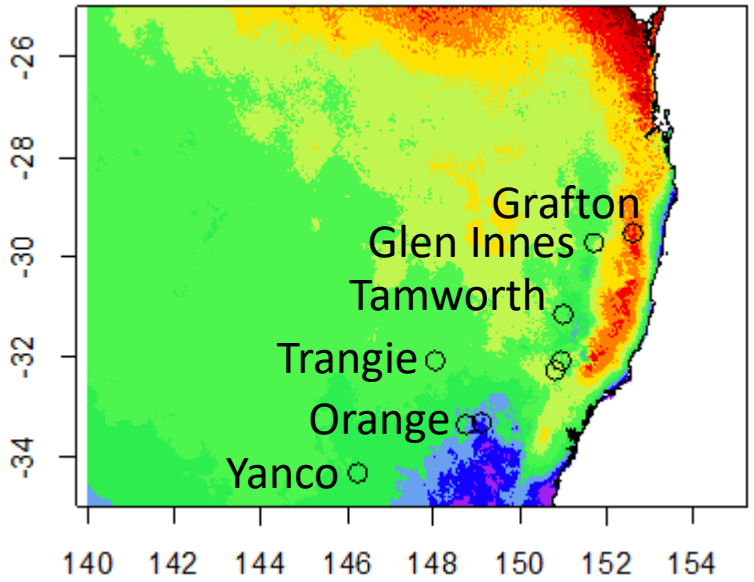


Monthly rainfall before and after trial establishment (blue bars)

Orange line is long- term monthly mean

Despite a dry start for 2019, trials conditions have been quite wet at all sites

Difference between historic rainfall (30 years to 2020) and projected annual rainfall 2061-80



Grafton +34 mm

Glen Innes -2 mm

Tamworth -7 mm

Trangie 0 mm

Scone -4 mm

Muswellbrook +2mm

Orange -33 mm

Cargo -21 mm

Yanco -12 mm

- Future climate will certainly be hotter (most models agree)
- Future rainfall variable, mostly lower in this model (models less certain and variable)
- Model used was CMIP6 CanESM5 2061-2080 30 second grid www.worldclim.org
- Other models may be more appropriate

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Future considerations & next steps

- Technical challenges with harvest, transport logistics, feedstock supply
- Coppicing performance is yet to be assessed for some species
- Silviculture and provenance trials (underway)
- Effect of a return to drier conditions
- Trials will continue to yield valuable info

E. infera

E. camaldulensis coppice after first harvest

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Summary

- Growing native trees for biomass energy can contribute to carbon neutral energy generation
- Several good species for different sites identified
- Tall tree species have done well initially
- Coppicing ability and adverse climate phases may favour hardier mallees in future
- Opportunity to integrate threatened species into plantings along with other biodiversity benefits
- The biomass trials have been a critical first step in developing a biomass resource in NSW

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