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Suitability of Victorian plantation-grown eucalypts for rotary veneer production

Master of Philosophy

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Project sponsorship

This study is part of a broader project jointly funded and delivered by Radial Timber Australia, the University of Melbourne, the Queensland Department of Primary Industries, the National Institute for Forest Products Innovation. The project has also been supported by Heartwood Unlimited and Incite Silviculture.

Scope of sponsored project

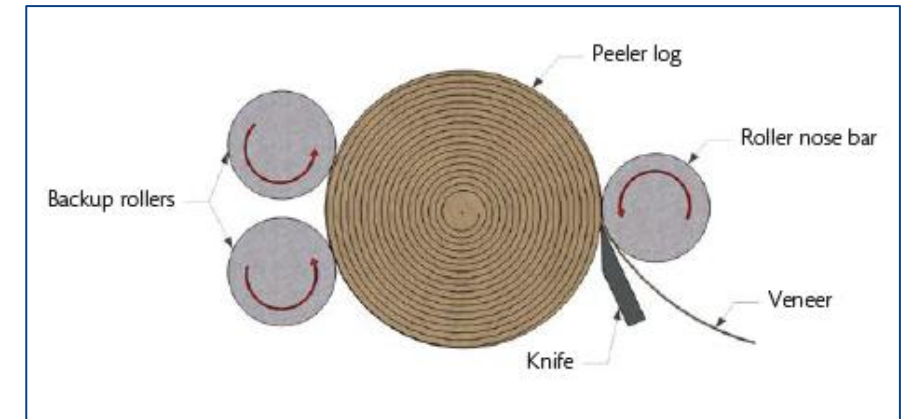
Evaluation of commercial opportunities for laminated veneer lumber from under-utilised forest resource in Gippsland.

Supervisors: Dr Robert McGavin, Dr Benoit Belleville, Professor Rod Keenan



We need more wood!

- **Timber availability supply gap**
 - Declining access to native forest supply, imports
 - By 2050, structural sawn timber supply expected to drop to 40% of demand!
- **Emerging availability of small diameter forest resources**
 - Mid-rotation plantation thinning, native ecological thinning
 - Processing limitations > under-utilised resource
- **How can we do more with less?**
 - Spindleless lathe technology = new processing opportunities for small diameter timber
 - Recoveries of > 60% are possible
 - Mechanical properties of hardwood veneer suitable for structural EWPs eg laminated veneer lumber (LVL)
 - Less waste, better return on investment for grower





Gap in knowledge

What do we know? Studies address:

- **Spindled lathes** – *E. nitens* (Nolan et al 2005)
- **International experience with spindleless lathes** (China, Vietnam, Laos) – Arnold et al 2013, Leggate et al 2017, Belleville et al 2018
- Green & dry veneer recovery, mechanical properties of **temperate and subtropical eucalypts** – *E. globulus*, *E. nitens*, *C. citriodora variegata*, *E. cloeziana*, *E. dunnii*, *E. pellita* (McGavin et al 2014, 2015)
- Preliminary green and dry veneer recovery, mechanical properties of Vic **temperate eucalypts** – *E. maculata*, *E. muelleriana*, *E. botryoides* (NIFPI research report)
- **Resource optimization and log utilization** for rotary veneer (Amishev & Murphy 2009, Dobner et al 2013, Venn et al 2013, McGavin et al 2020)

What don't we know? Limited studies on:

- Detailed veneer quality and recovery data from international experiences
- Suitability of **Victorian hardwood plantation species** (log geometry, veneer quality)
- *C. maculata*, *E. muelleriana*, *E. botryoides*, *E. sieberi*, *E. tricarpa*, *E. cladocalyx*, *E. bosistoana*, *E. globulus*, *E. saligna*, *E. nitens*.
- Suitability of **mid-rotation low grade thinnings**
- Impact of **plantation management** on plantation feedstock suitability
- **Log specification tools** for rotary veneer
- **Quantities available** of suitable resource in different Aust wood supply catchments
- **Market value and economics** of alternative resource utilization regimes in Aust hardwood⁴ plantations

Feedstock suitability characteristics for rotary veneer:

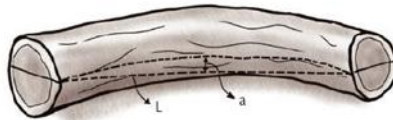
What does good look like?

Log geometry dictates green veneer recovery:

- Venn et al (2020) suggests order of influence: sweep > diameter > taper > ovality
- A significant determinant of overall volume & revenue of veneer produced

Sweep:

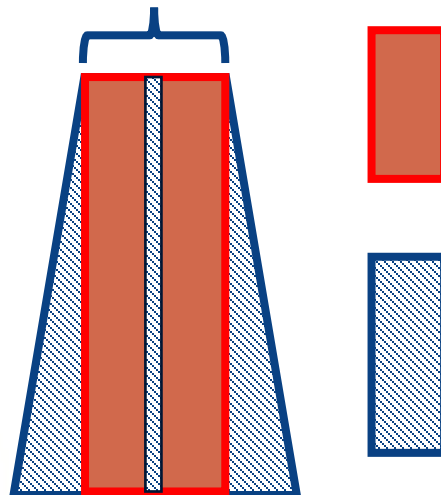
Effective diameter = SEDUB - sweep



Ovality:



SEDUB



Green veneer recovery: can be predicted by rounded billet volume (less peeler core) - primarily influenced by small end diameter under bark (SEDUB)

Green waste:

- Difference in volume between pre-rounded log and the cylindrical rounded billet, plus
- Peeler core volume (~ typically 4-5cm diameter)

Feedstock suitability characteristics for rotary veneer:

What does good look like?

Branch (geometry) dictates knot & knot related defects

- Defects influence structural and visual qualities of veneer
- Veneer grades defined by AS/NZS 2269.0:2012 structural plywood standard
- 4 grades of acceptability
- Knots often limit quality to lowest acceptable grade (D)
- Can we identify acceptability thresholds for branch diameter and angle that correspond to knot width thresholds in the grading standard?



A grade value
= D grade value x 3



B grade value =
D grade value x 1.7



C grade value =
D grade value x 1.2



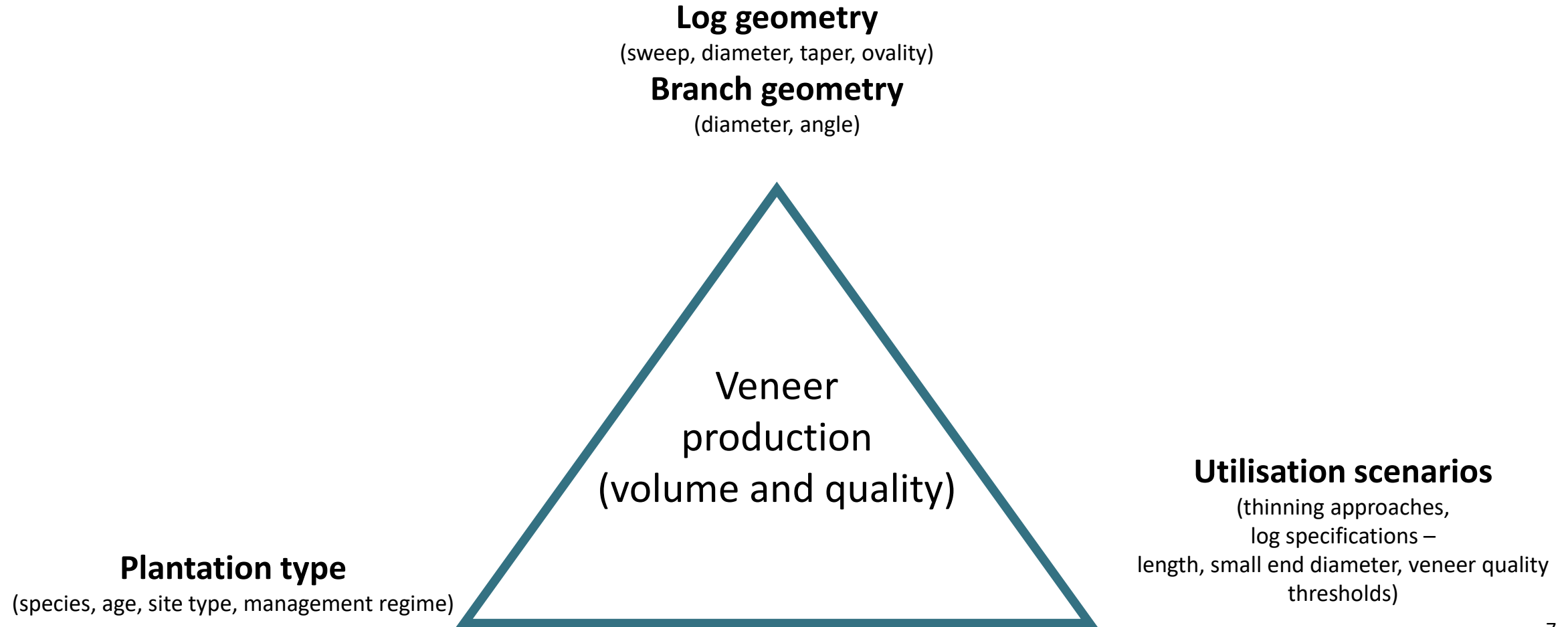
D grade



F grade

Feedstock suitability characteristics for rotary veneer:

What does good look like?





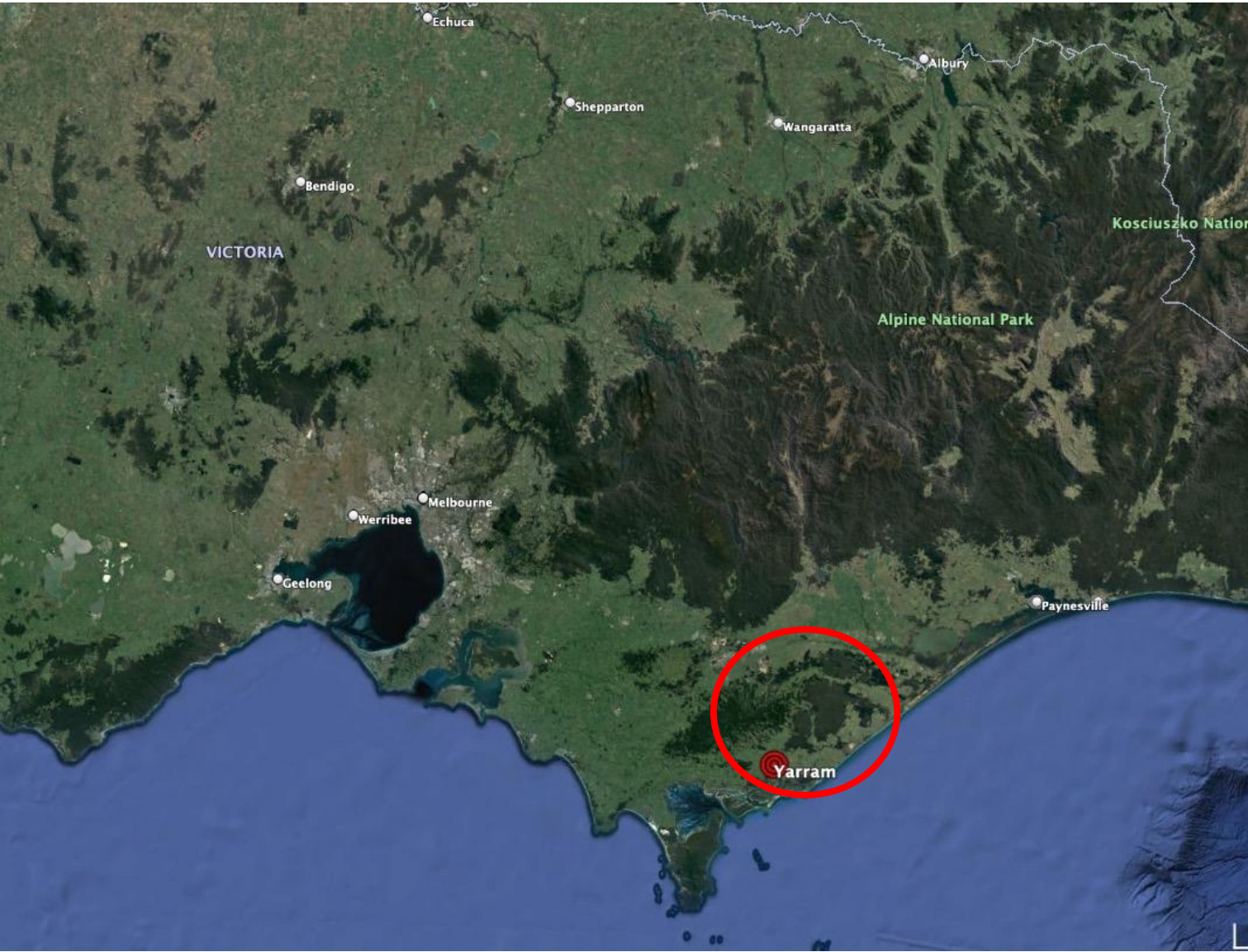
Objectives/Methods - Overview

Research Objectives	Methods
1: to predict/ compare the green veneer recovery for a range of hardwood plantation types	• Non-destructive plantation inventory (DBH, sweep) • Destructive taper sampling • Green veneer volume calculations
2: to estimate the green veneer recovery for a range of log selection scenarios	• Sensitivity analysis: green veneer volume calculations under different log specification scenarios
3: to assess whether branch geometry can be used to predict the impact of knot related defects on veneer quality.	• Branch measurements of plantation resource • Peeling logs, measurement of knots in veneer • Analyse branch-knot relationships
4: to identify non-destructive tree/log/branch thresholds of acceptability that indicate differing levels of suitability >> peeler-tree selection tool	• Use outcomes of branch-knot assessment and utilisation analysis to propose suitability thresholds for veneer tree/ logs selection.

Log geometry – selecting test plantations

Selected target estate:

- Radial Timbers' hardwood plantation estate in Gippsland (managed for high value sawlog product)



Log geometry – selecting test plantations

Root stocking range (stems per ha) for test plots

Site ID	Age (yrs)	Southern Mahogany	Spotted Gum	Yellow Stringybark	Site Type	Locality
1 (HOL)	9.5	364-406			Gippsland Plains	Yarram
2 (MCM)	10.5		273-395	290-342	Gippsland Plains	Darriman
3 (FIN)	11.5			393-450	Strzelecki Hills	Carrajung Lower
4 (BCK)	12.5	277-425	368-434		Strzelecki Hills	Won Wron
5 (MRS)	14.5	250-394	315-348	316-379	Gippsland Plains	Darriman
6 (ASK)	14.5	228-300			Gippsland Plains	Alberton West
6 (ASK)	17.5		293-376	200-215	Gippsland Plains	Alberton West

- 3 species, 2 site types, 4 sites per species (3-4 ages classes per species)
- 3 plots per species per site, stratified random positioning
- Overall root stem stocking ranging from 200-450sph)
- Each plantation at a different stage of a sawlog management regime (pruning to 6m over 3 lifts, periodic thinning)

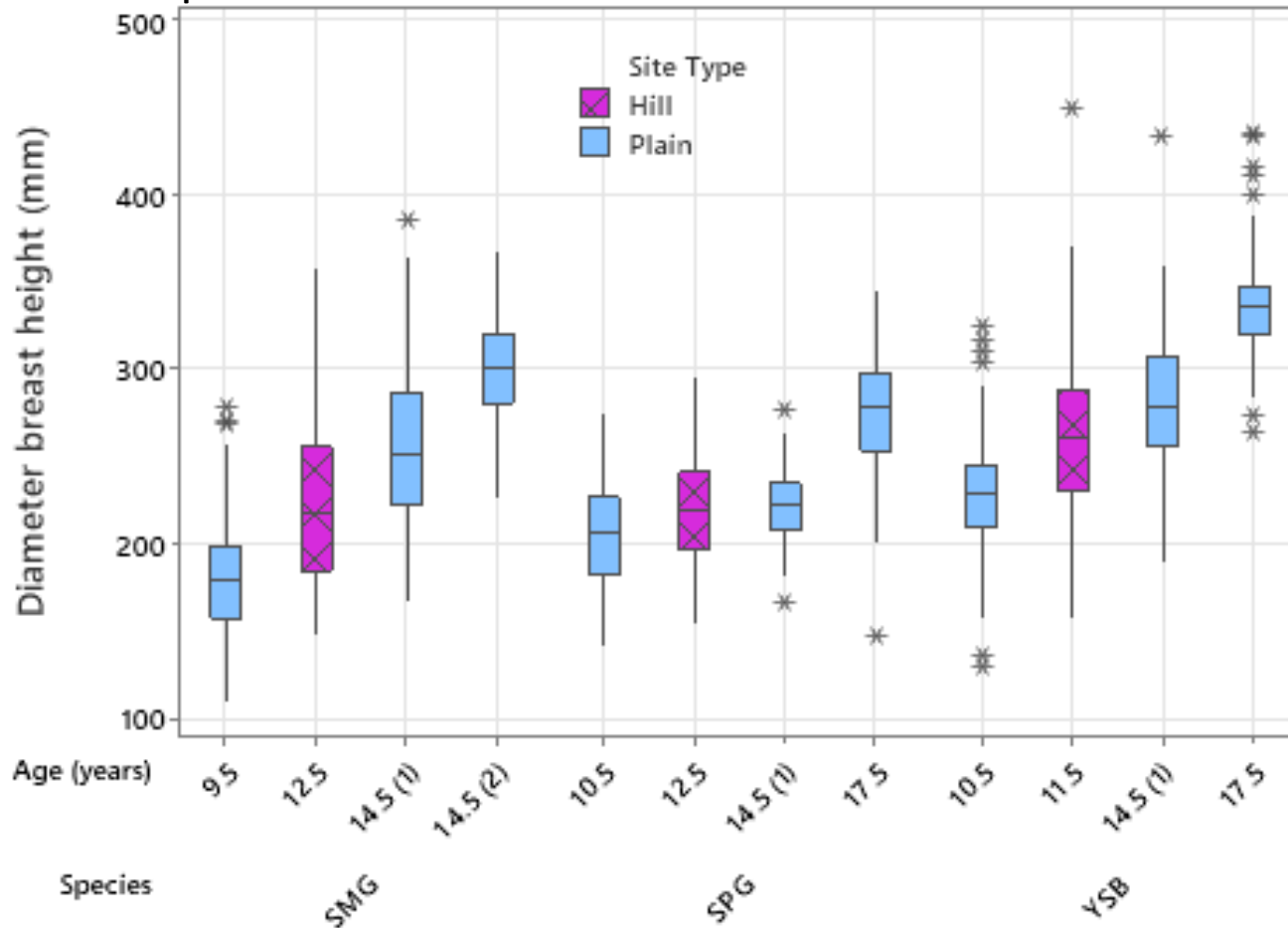
Measuring log geometry: non-destructive and destructive

- **Inventory plots:** DBH, prune status, sweep, log limiting defects (max merchantable height)
- **Taper tree samples:** disc diameters at 2m log increments (to SEDUB 10cm)



Diameter Breast Height Over Bark (at 1.3m)

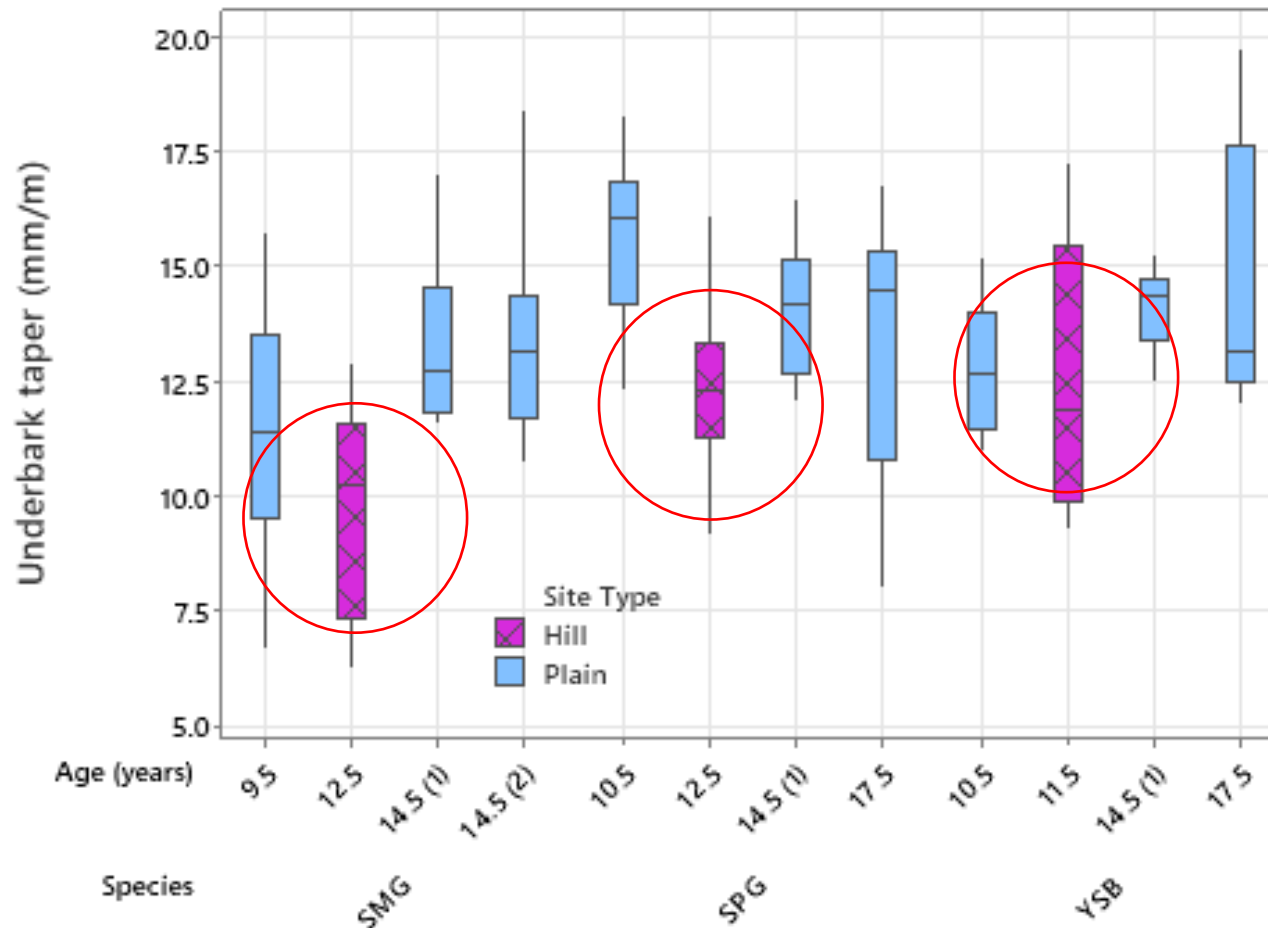
DBHOB (mm) per plantation – box plot



- Mean DBH per plantation ranged from 181 – 338mm for age classes ranging from 9.5 – 17.5yo
- (target SEDUB: 100mm, 150mm, 200mm)
- Age was the key factor influencing DBH

Taper (under-bark)

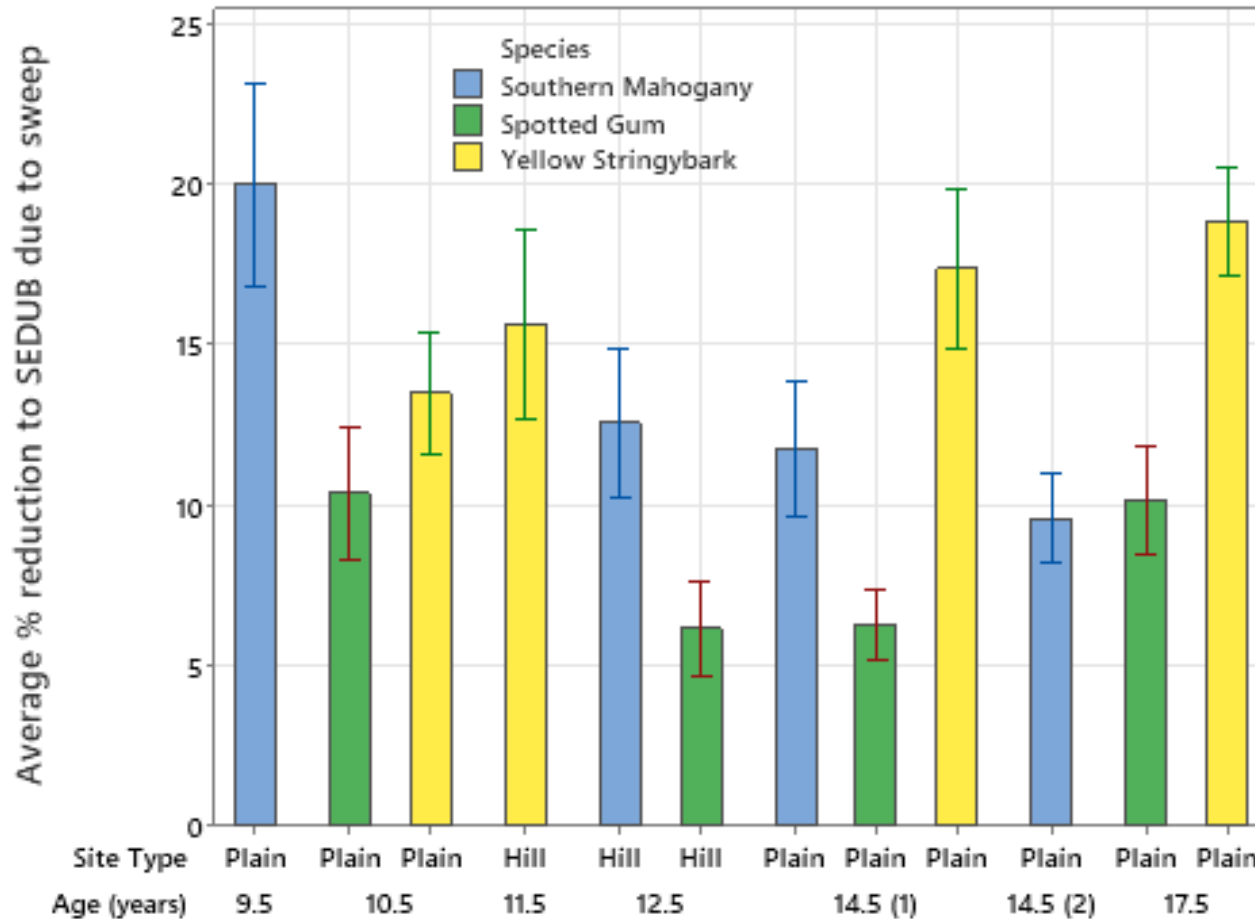
Under-bark taper per plantation (mm/m) – box plot



- Mean taper per plantation ranged from 9.78 – 14.61 mm/m
- No significant differences due to age
- Spotted Gum significantly different from Southern Mahogany
- “Hill” sites exhibit significantly lower taper than “plains” sites
 - Hill sites: higher rainfall, fertility & stocking
 - Plain sites: lower rainfall, fertility & stocking

Sweep

% of billet small end diameter reduction due to sweep



Presence of sweep in the plantations

% of stems exhibiting sweep per plantation: **58% – 90%**

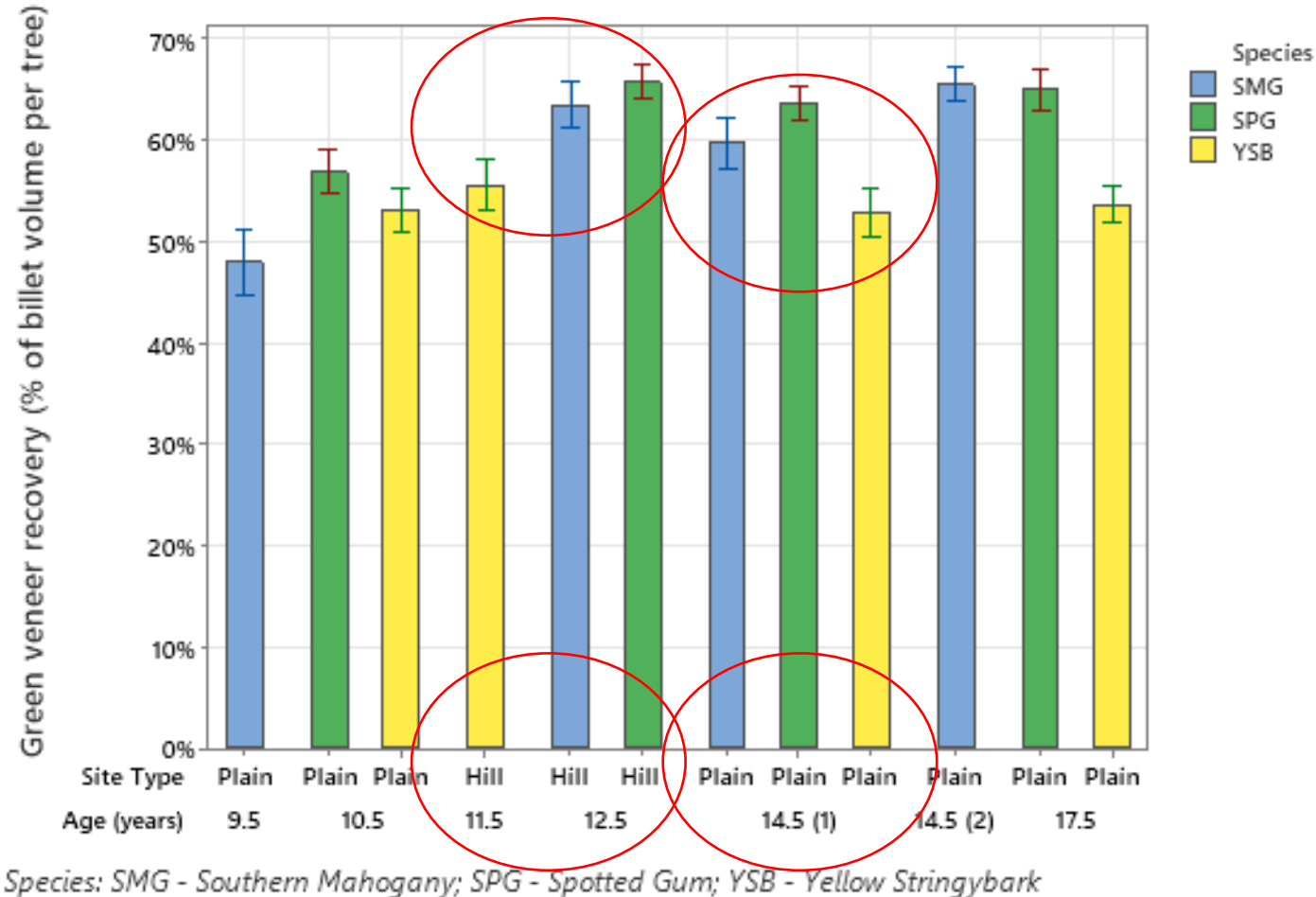
Yellow Stringybark > Southern Mahogany > Spotted Gum

Impact of sweep on billet diameter

Average % reduction to billet SED due to sweep: **6% - 20%**

Yellow Stringybark (16%) > Southern Mahogany (13%) > Spotted Gum (8%)

Green veneer volume recovery % per tree



Species averages:

Spotted Gum (62.75%) > Mahogany (58.5%) > Yellow Stringybark (54%)

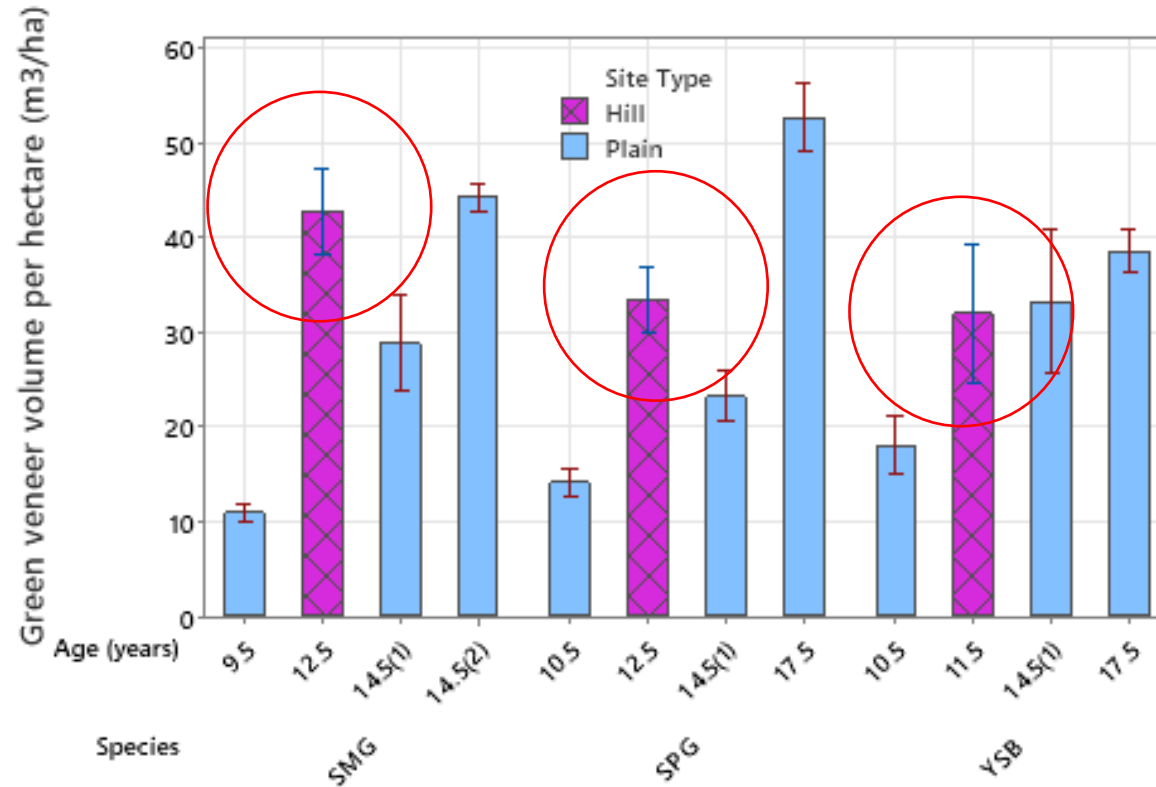
- Plantation averages ranged from 48 – 66%
- Minimal variation due to age
- **Better recovery for:**
 - **Sites with lower taper** (hill sites – higher rainfall, fertility, stocking)
 - **Species with lower sweep** (Spotted Gum)
- **Comparable to previous studies of spindleless lathe log conversion:**
 - International studies 2013 – 2018: 52-63%
 - McGavin et al (Aust hwd plantations) 2014-2015: 68-77%
 - NIFPI 2025 (Gippsland hwd plantations): 76-82%

Volume estimations assume: “**clear-fall event**”

Log length: 2.6m; minimum **SED:** 100mm

Green veneer volume per hectare

Volume (m³/ha) per plantation



Species: SMG - Southern Mahogany; SPG - Spotted Gum; YSB - Yellow Stringybark

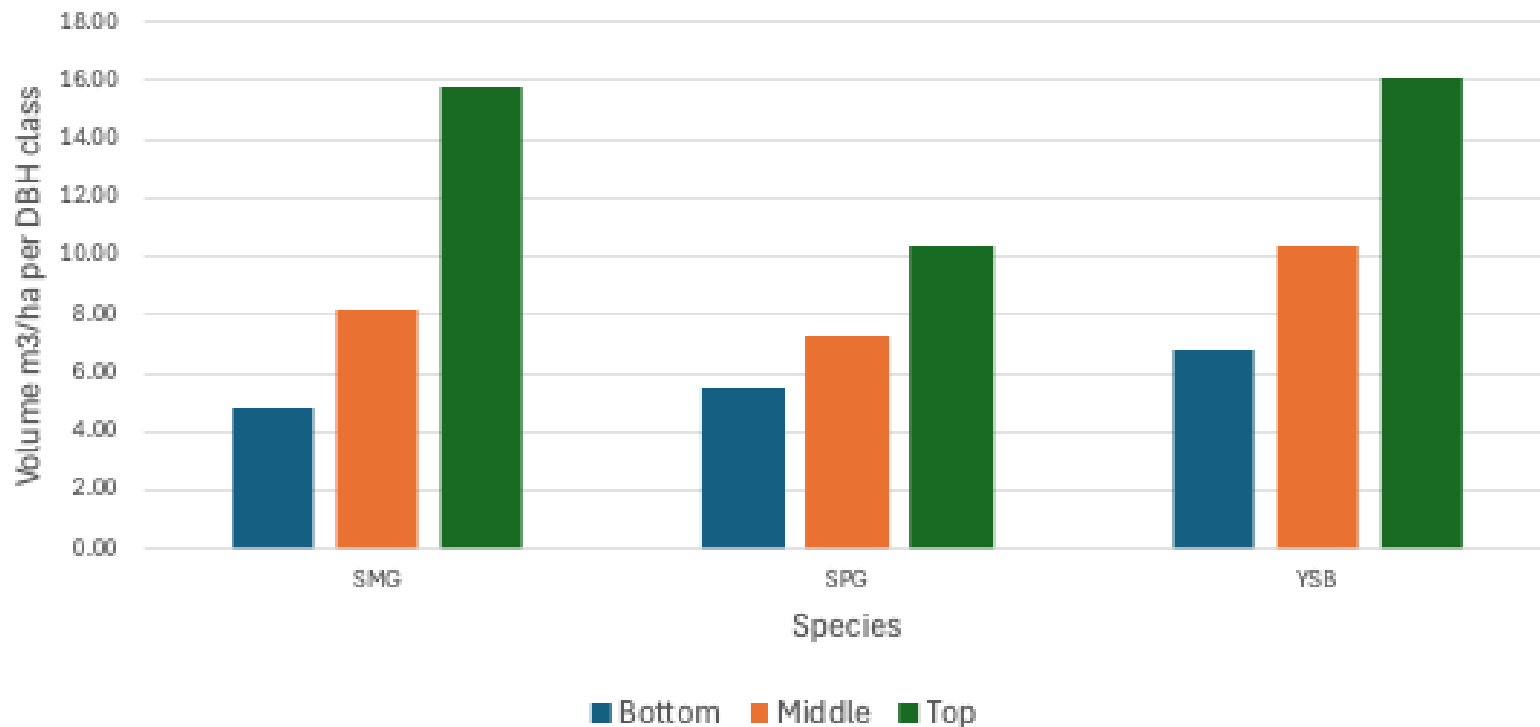
Volume estimations assume: “**clear-fall event**”

Log length: 2.6m; minimum **SED:** 100mm

- Mean volume per plantation ranged from 11 – 53 m³/ha
- Better performance for:
 - Older age classes
 - Sites with lower taper (hill sites)
- No significant different due to species (relative species ranking is inconsistent between sites)

Volume distribution by DBH class (indicates volume available if thinning from above or below)

Volume (m³/ha) distributed between DBH classes split into thirds -
(14.5yo plantation - MRS)



**DBH size class thresholds - this site
(equal thirds per site DBH range)**

Upper limit of bottom thresholds
range from 215 – 264mm

Lower limit of upper thresholds
range from 230 – 290mm

Volume available per DBH class:

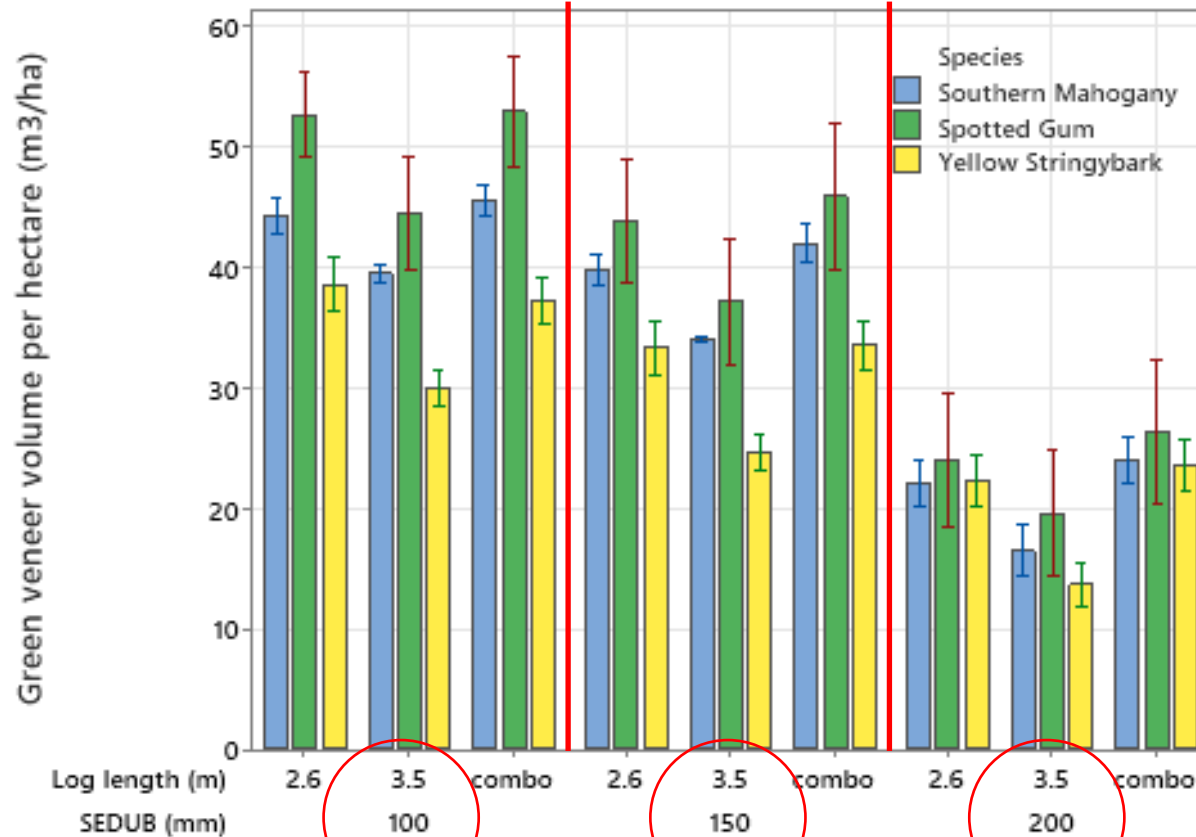
Bottom: ~ 17 – 24% (5-8m³/ha)

Mid: ~ 28 – 32% (7-10 m³/ha)

Top: ~ 45-55% (23-33 m³/ha)

Green veneer volume per ha x 9 log dimension scenarios

Example: 17.5yo spotted gum site (ASK)



Example: 17.5yo spotted gum site:

Green volume estimate range (m³/ha) x 9 scenarios:

Max: 53 m³/ha (SED 100mm, combo log length)

Min: 20 m³/ha (SED 200mm, 3.5m log length)

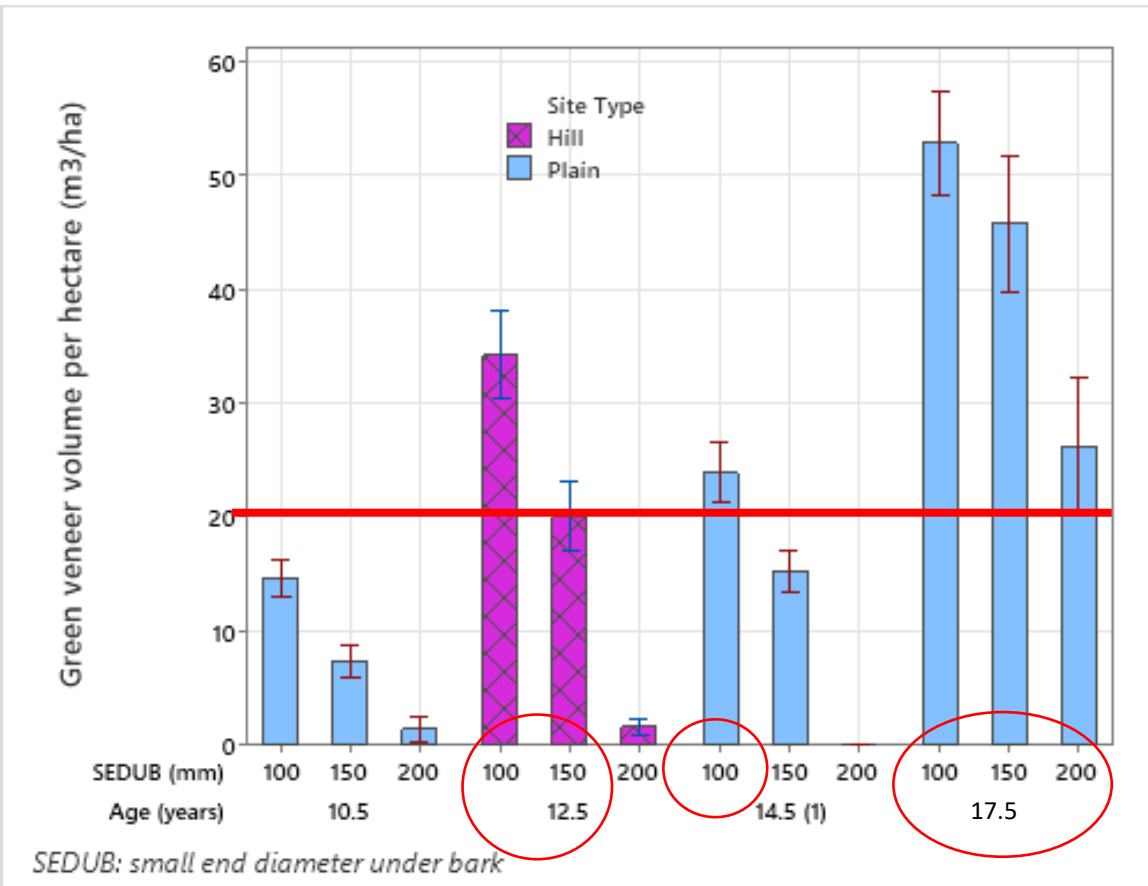
- SEDUB more influential than log length
- Combo log length achieves best volume output

3 SEDUB scenarios: 100mm, 150mm, 200mm

3 log length scenarios: 2.6m, 3.5m, combination

Identifying age-based thresholds for volume production

Example: spotted gum



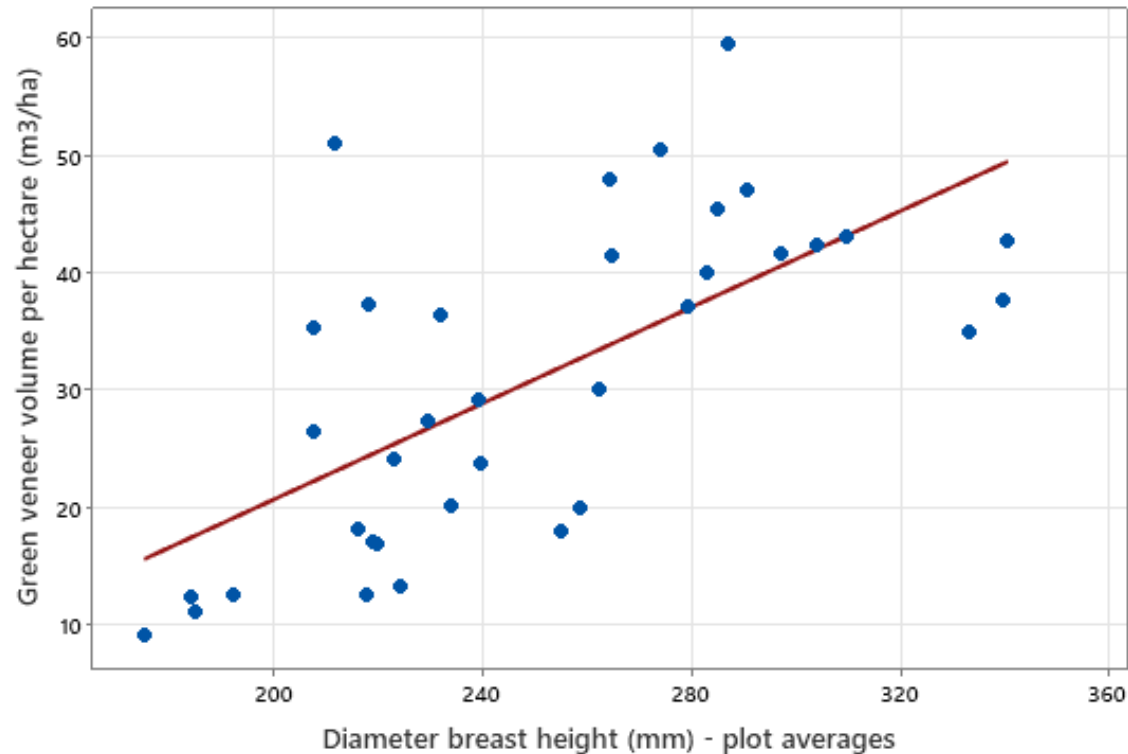
- Available volume increases with age for all log dimension scenarios
- Use crude yield charts per species to identify age thresholds associated with volume thresholds
- **Spotted Gum example:** setting an arbitrary 20m³/ha minimum volume threshold
 - 3 of 4 plantations would meet the criteria
 - Only oldest plantation could service all SEDUB scenarios (assuming combo log length)
 - This chart assumes clear-fall yield

3 SEDUB scenarios: 100mm, 150mm, 200mm

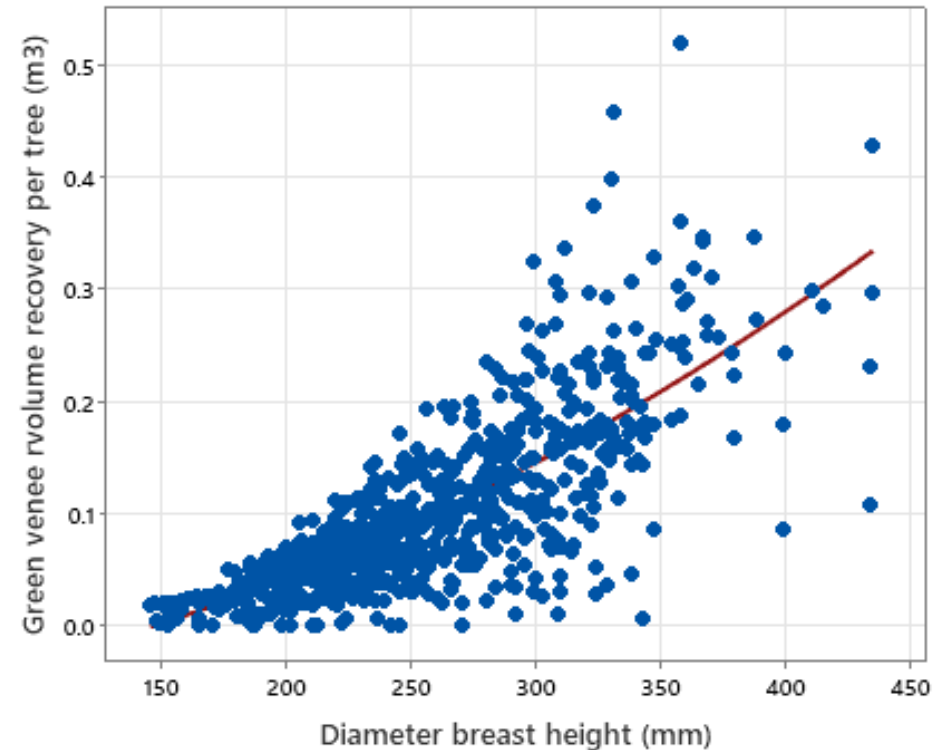
Log length scenario: combination 2.6m + 3.5m (gives best result)

Identifying DBH thresholds for volume production

DBH x volume (m^3) recovery per hectare
(correlation coefficient: 0.667)



DBH x volume (m^3) per tree
(Correlation coefficient: 0.776)



Use to develop models to identify DBH thresholds that correspond to volume production thresholds

Branching/ knot assessment

Target 3 species, one site ("ASK" – 17.5yo Gippsland Plains site)

Sample range of branch types – size, angle class, living & dead

Measure impact of knot related defects in veneer for each branch sample

44 trees > 79 logs > 428 branches > 2428 knots!

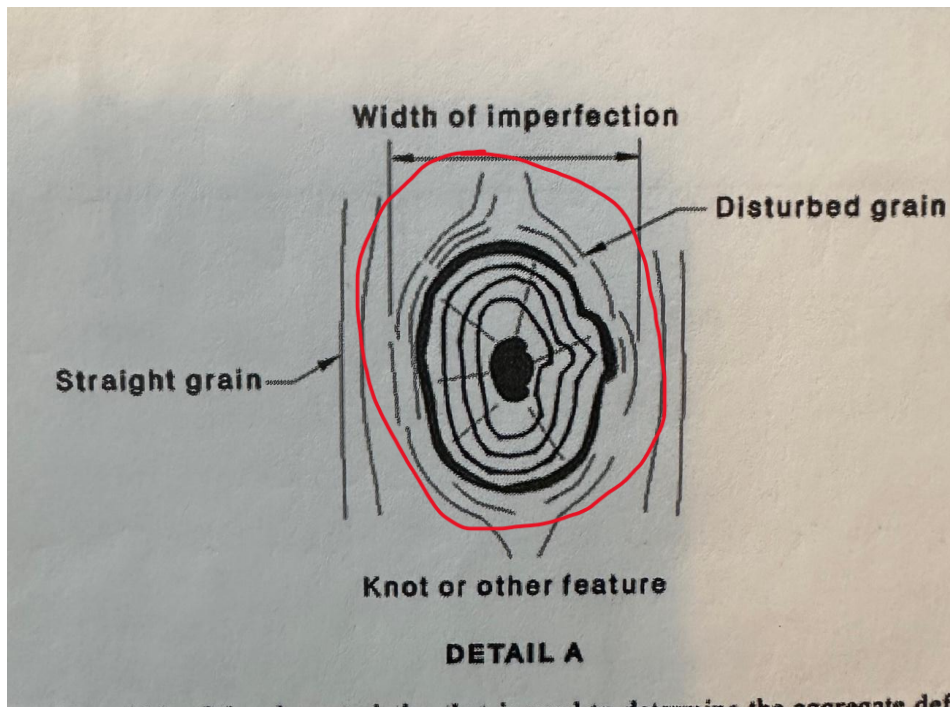


Peeling of logs at Radial Timber Australia (spindleless lathe facility, Yarram)



Knot measurement & analysis

AS/NZS 2269.0:2012 structural plywood standard used to guide knot boundary identification

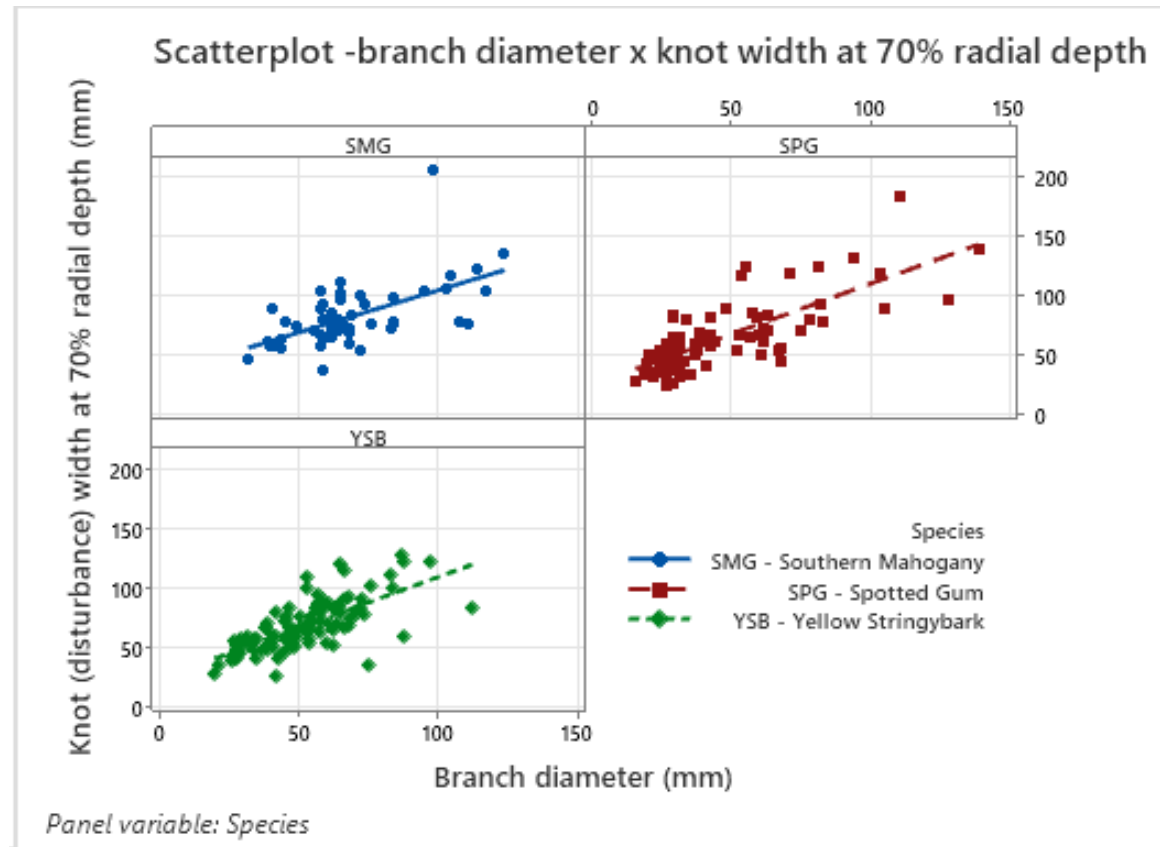


- Focused on knot disturbance width
- Measured 4-6 knot occurrences per branch series (every 3rd knot in veneer ribbon)
- Linear regression used to assess associations:
 - Knot width x radial depth
 - Knot width x branch diameter
 - Knot width x branch angle
- Linear mixed models used to:
 - Assess significance of correlations
 - Estimate branch diameter and angle thresholds that correspond with knot width thresholds from grading standard

NOTE: The width of the characteristics that is used to determine the aggregate defect dimension shall include the disturbed grain adjacent to the characteristics.

Knot width correlations

E.g. knot width x branch diameter at 70% radial depth

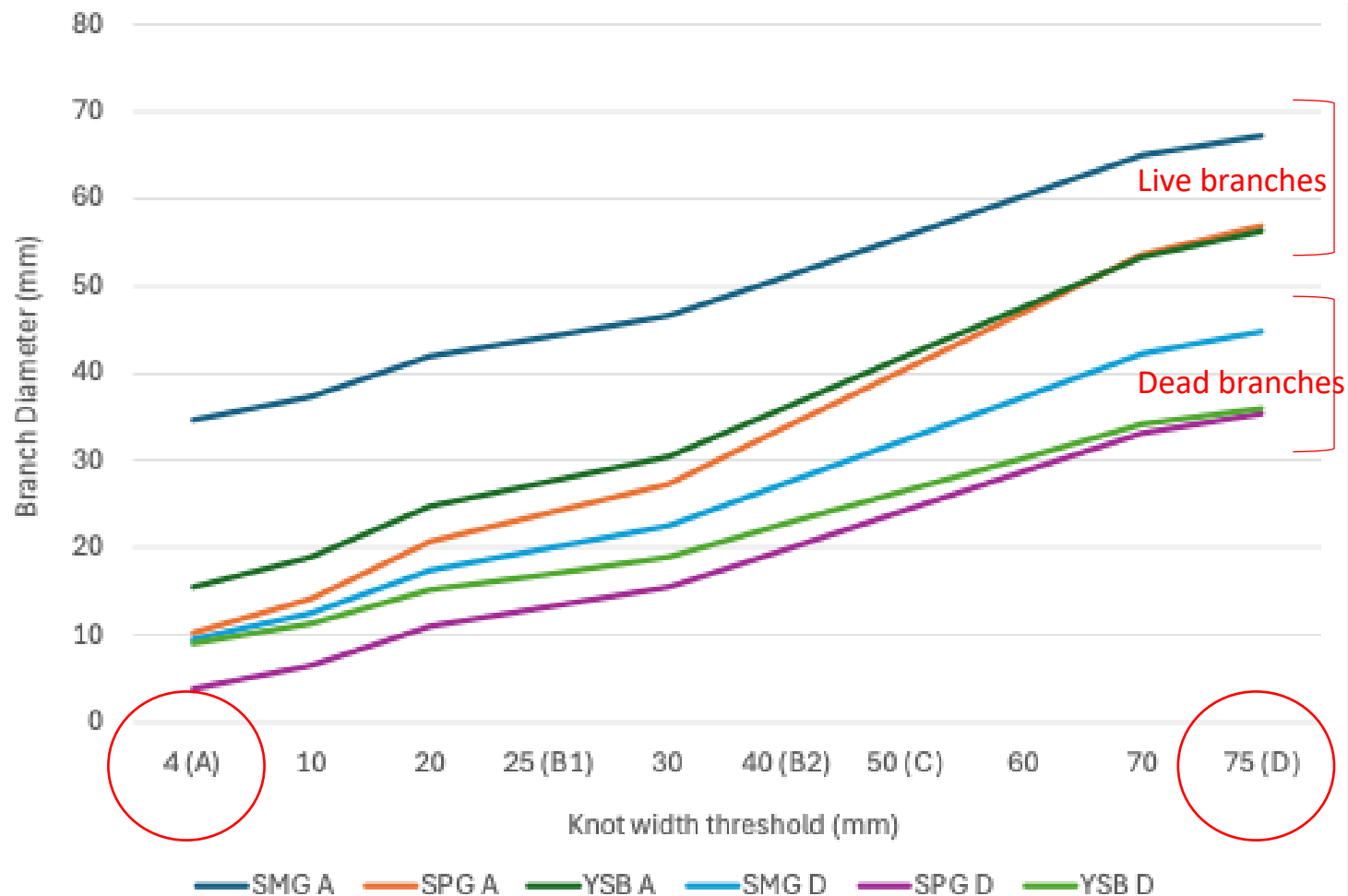


Pearson's correlation coefficients – all species combined

Association parameters	Live	Dead
Knot width x radial depth	0.390	0.226
Knot width x branch diameter	0.728	0.786
Knot width x branch angle	0.352	0.599

- Correlations strong enough to assume association for all pairings
- Knot width positively correlated with radial depth and branch diameter
- Knot width negatively correlated with branch angle
- Correlations warrant developing models to predict knot width for a given branch diameter or angle

Estimating branch diameter thresholds (branch group comparison at 70% radial depth)



- This analysis assumes a knot can be assigned a “grade” according to the grading standard (ignores the requirement of the standard to consider knot frequency/ distribution).
- **Knot widths defined by the standard:** grade A (4mm); B1 (25mm); B2 (40mm); C (50mm); D (75mm)
- Branch diameter tolerances are greater for larger knot widths (acceptable at lower quality grades)
- Tolerances are more lenient for live knots than dead knots

Estimating branch diameter thresholds (rounding up to nearest 10mm for practical application)

Example: branch diameter thresholds at **70%** radial depth

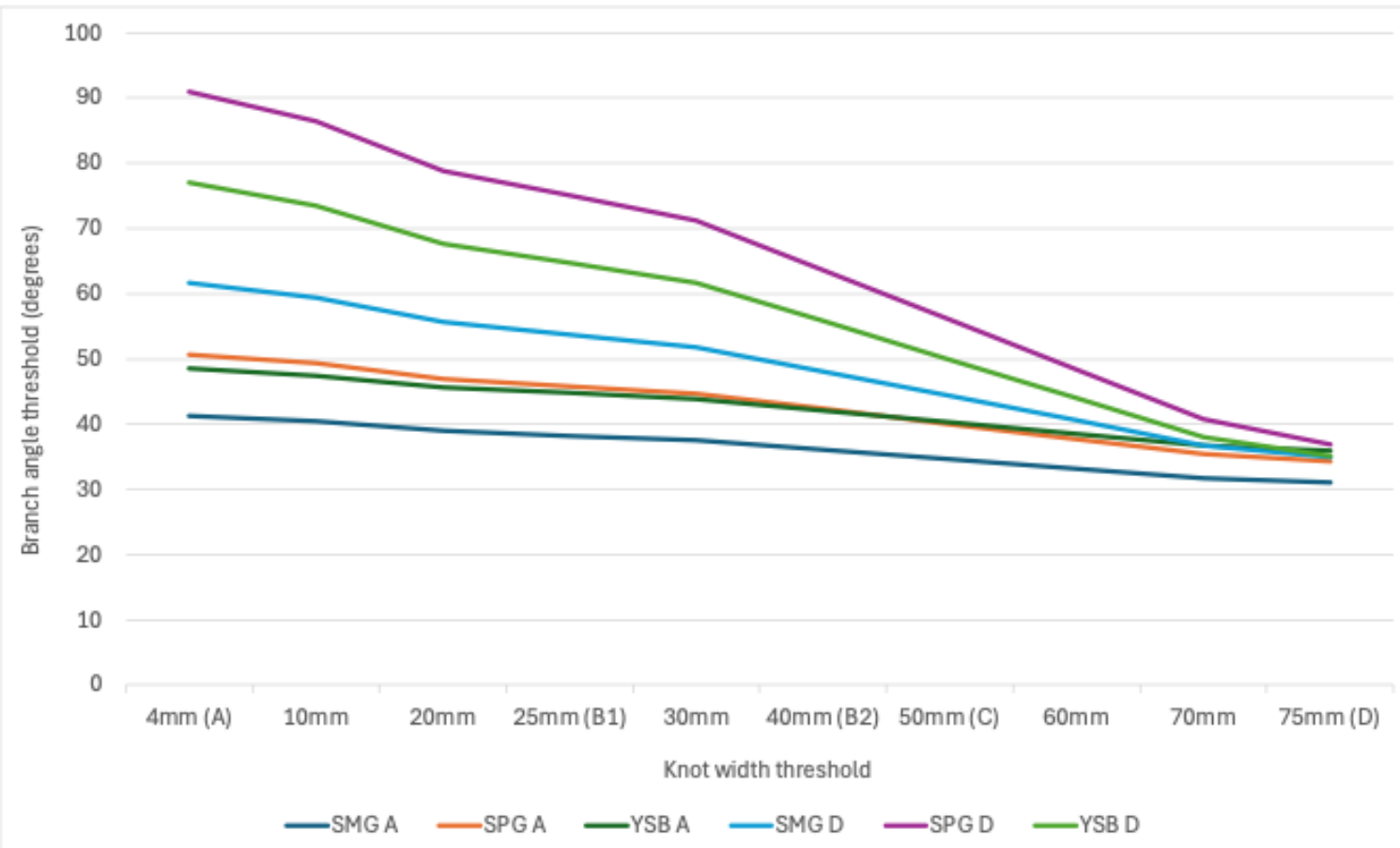
Knot width threshold (mm)	Veneer grade	Branch diameter (mm) at 70% radial depth per group for disturbance width metric					
		Live branches (1)			Dead branches (1)		
Species		SMG	SPG	YSB	SMG	SPG	YSB
4	A	40	20	20	10	10	10
75	D	70	60	60	50	40	40

Example: rounded branch diameter thresholds – all species

		Proposed maximum branch diameter threshold (mm)	
Branch group	Target grade quality	Rounded up (less conservative)	Rounded down (more conservative)
Live	A	20	10
	D	60	50
Dead	A	10	0
	D	40	30

- What is the practical difference between thresholds at different radial depths or branch groups?
- What is the impact of rounding up vs rounding down (~ 10mm reduction)
- How do these thresholds compare to protocol previously applied in some Qld studies?
 - Live branches $\leq 60\text{mm}$
 - Dead branches $\leq 30\text{mm}$

Estimating branch angle thresholds (branch group comparison at 70% radial depth)



- Wider knot thresholds equate to narrow branch angle tolerances – (approx. 30-35°)
- Narrower knot thresholds equate to wider branch angle tolerances (approx. 40-90°)
- Live branches allow narrower tolerances than dead branches

	Angle thresholds (rounded all species)	
Target grade threshold	Live	Dead
A	> 45°	> 45°
B1	> 45°	> 45°
B2	> 30°	> 45°
C	> 30°	> 45°
D	> 30°	> 30°

SMG: southern mahogany; SPG: spotted gum; YSB: yellow stringybark

Applying this study in practice

This study allows us to be better able to:

- **Predict** expected peeler log **volume outputs** and veneer quality for Gippsland hardwood plantation types and geometry-based utilisation scenarios
- Inform **plantation management choices** that could optimise plantation suitability (tree and branch geometry) for peeler log production
- Inform **recommendations to processors** for optimizing log utilisation for veneer production
- Develop **log procurement and tree selection protocols**
- **Next step:** economic study to define **commercially acceptable thresholds of production** that can help identify visually observable thresholds of acceptability for tree, log and branch specifications (eg DBH, branch diameter/ angle, sweep severity)



What next?

Log geometry/ volume study – further research:

- Refine sweep impact measurement and modelling
- Assess wider range of plantation types & management regimes
- Economic and market analyses to help define commercial volume production thresholds of acceptability – how much is enough?
- Refine tree/log selection specifications/ thresholds

Branch/ knot study - further research

- Assess knot related defect type & severity (soundness, knot holes, decay, bark & kino pockets)
- Assess relationship between knot frequency & log diameter (cumulative defect)
- Assess branch type frequency/ severity of occurrence in Gippsland hardwood plantation estate



Questions?

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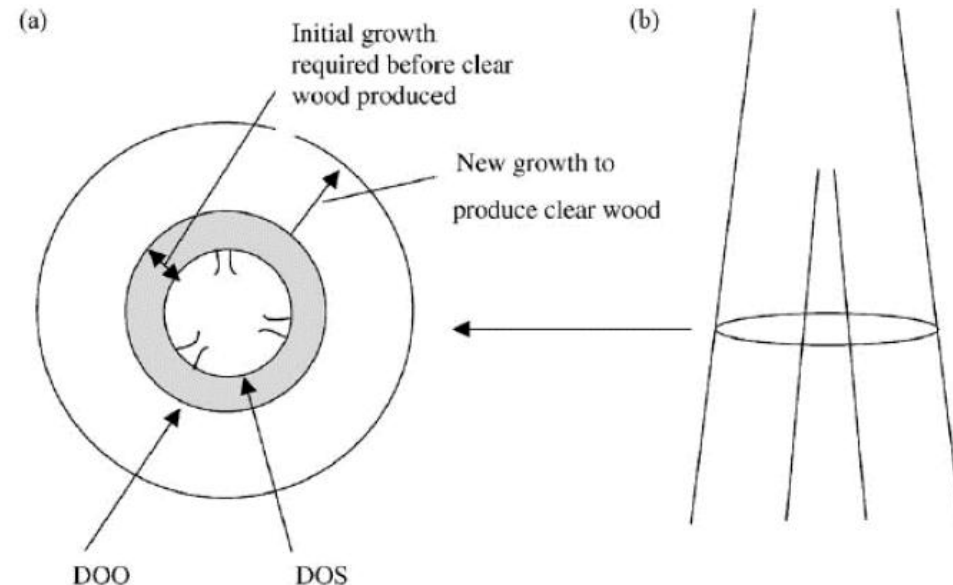
Extra slides/ data

Feedstock suitability characteristics for rotary veneer:

What does good look like?

Influence of branching:

- Knots from branching often limit quality to lowest acceptable grade (D)
- Can we identify acceptability thresholds for branch diameter and angle that correspond to knot width thresholds in the grading standard?



Benefits of the study

The study will aim to inform:

- **Recommendations to plantation managers** for optimising resource management and harvesting protocols for veneer log production
- **Recommendations to processors** for optimising log utilisation for veneer production
- **Log procurement & tree selection protocols** for forest managers and harvesting practitioners
- **A foundation for further research** into:
 - Economic implications of different utilisation scenarios for the supply chain
 - Implications of veneer quality for engineered wood product development options
 - Efficient harvest and haulage protocols for multi-product plantation resource extraction
 - Impact of species choice and plantation management methods on veneer log and sawlog production

Objectives & research questions

Question 1: *How do select Victorian hardwood plantations perform against visually observable veneer log suitability characteristics such as log geometry and branching?*

- **Objective 1:** To predict and compare the green veneer recovery performance of a range of hardwood plantation types representative of selected species, site types and management regimes across Victoria.
- **Objective 2:** To determine whether tree branch assessment can be used to predict the impact of knot and knot related defects on veneer quality.

Question 2: *How can visually observable tree characteristics be used to model resource utilisation to define rotary veneer suitability thresholds for Victorian hardwood plantation species?*

- **Objective 3:** To estimate the resource utilisation outcomes of a range of log selection scenarios
- **Objective 4:** To identify threshold tree and log parameters (non-destructive) that indicate differing levels of suitability for veneer production, to be used to generate a peeler-tree selection tool.

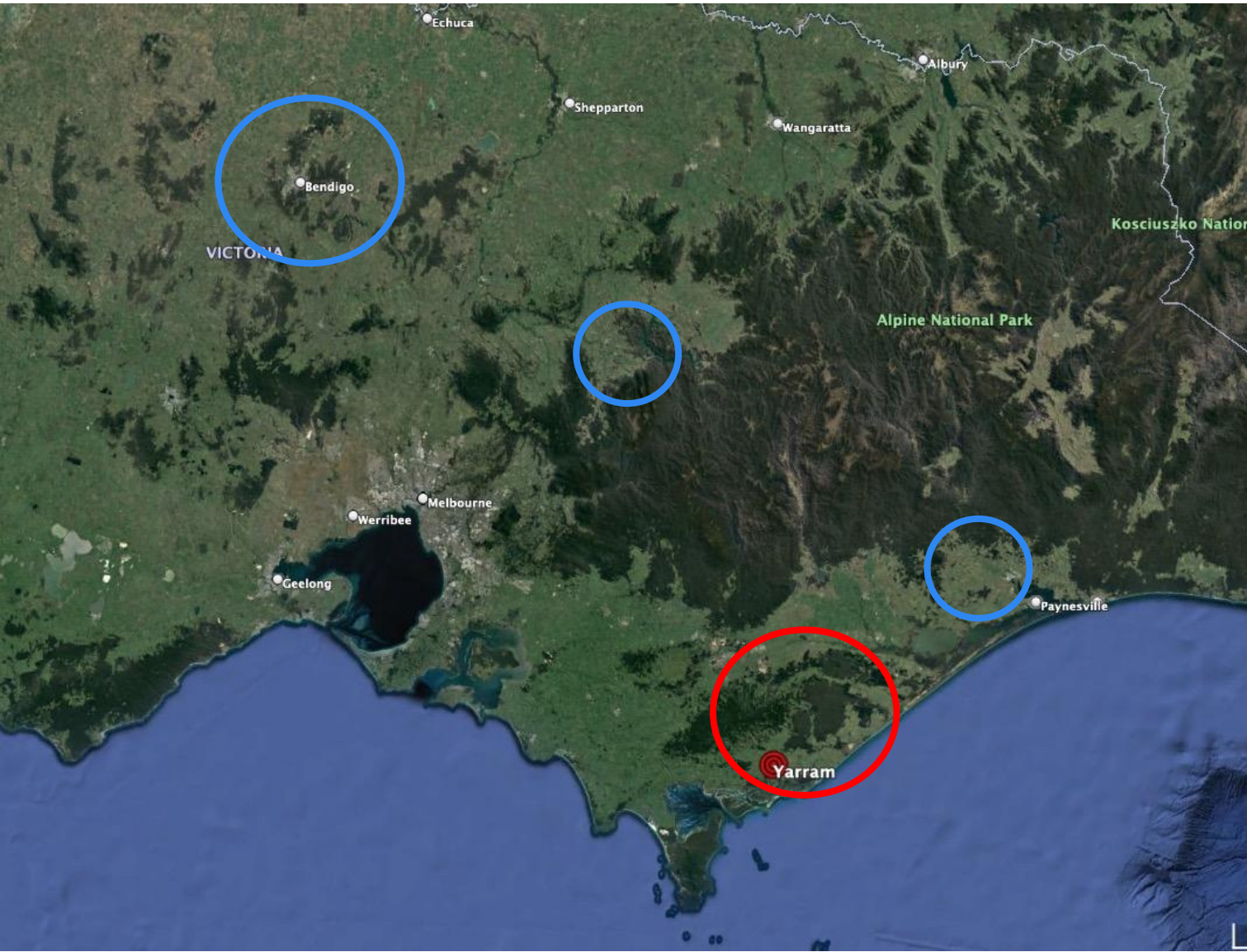
Log geometry – selecting test plantations

Selected target estate:

- Radial Timbers' hardwood plantation estate in Gippsland (managed for high value sawlog product)

Other resources considered:

- Other hardwood plantation estates considered (East Gippsland, Central Victoria, Gold Fields)

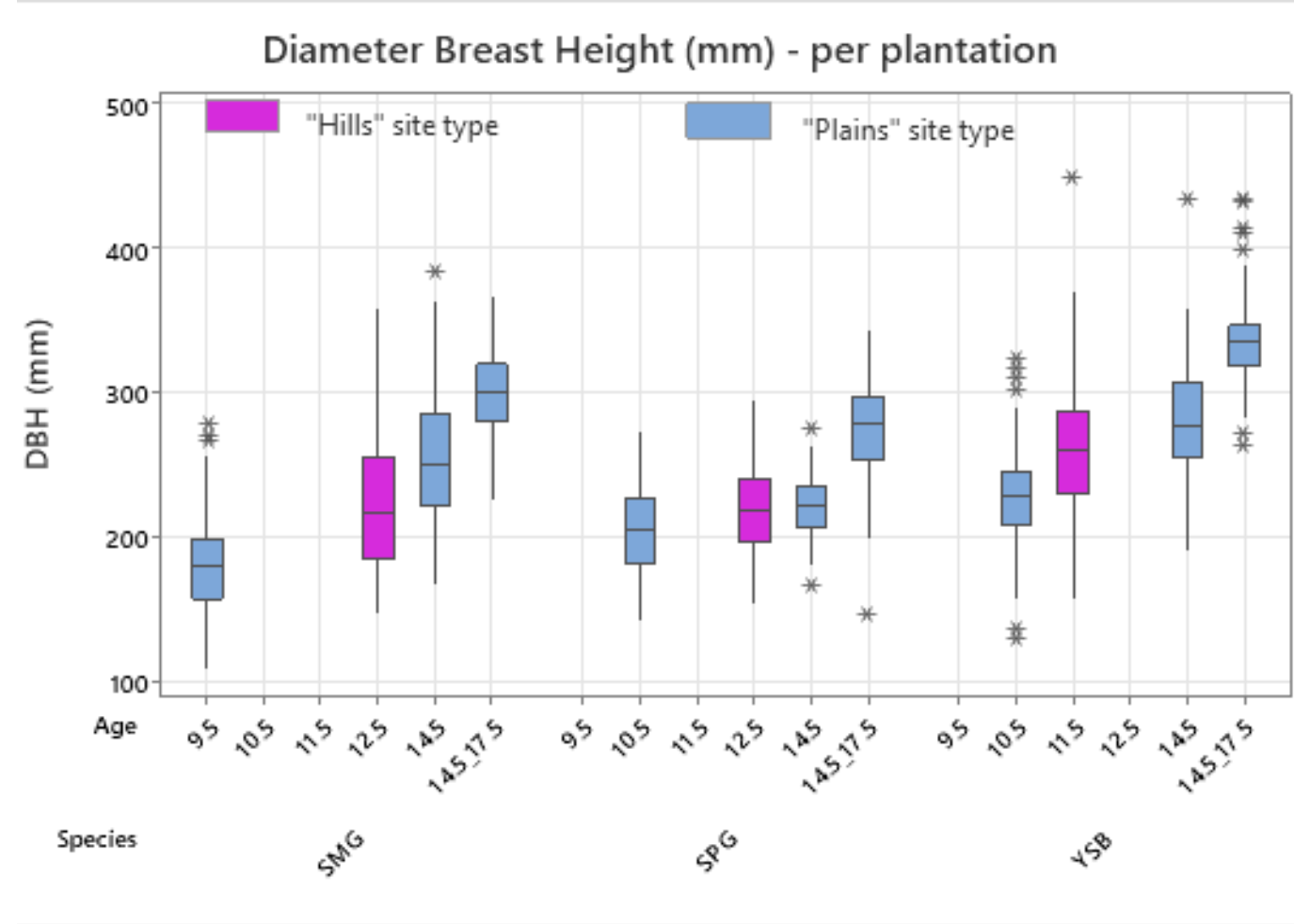




Diameter Breast Height (1.3m)

DBH means (range) (mm) per plantation

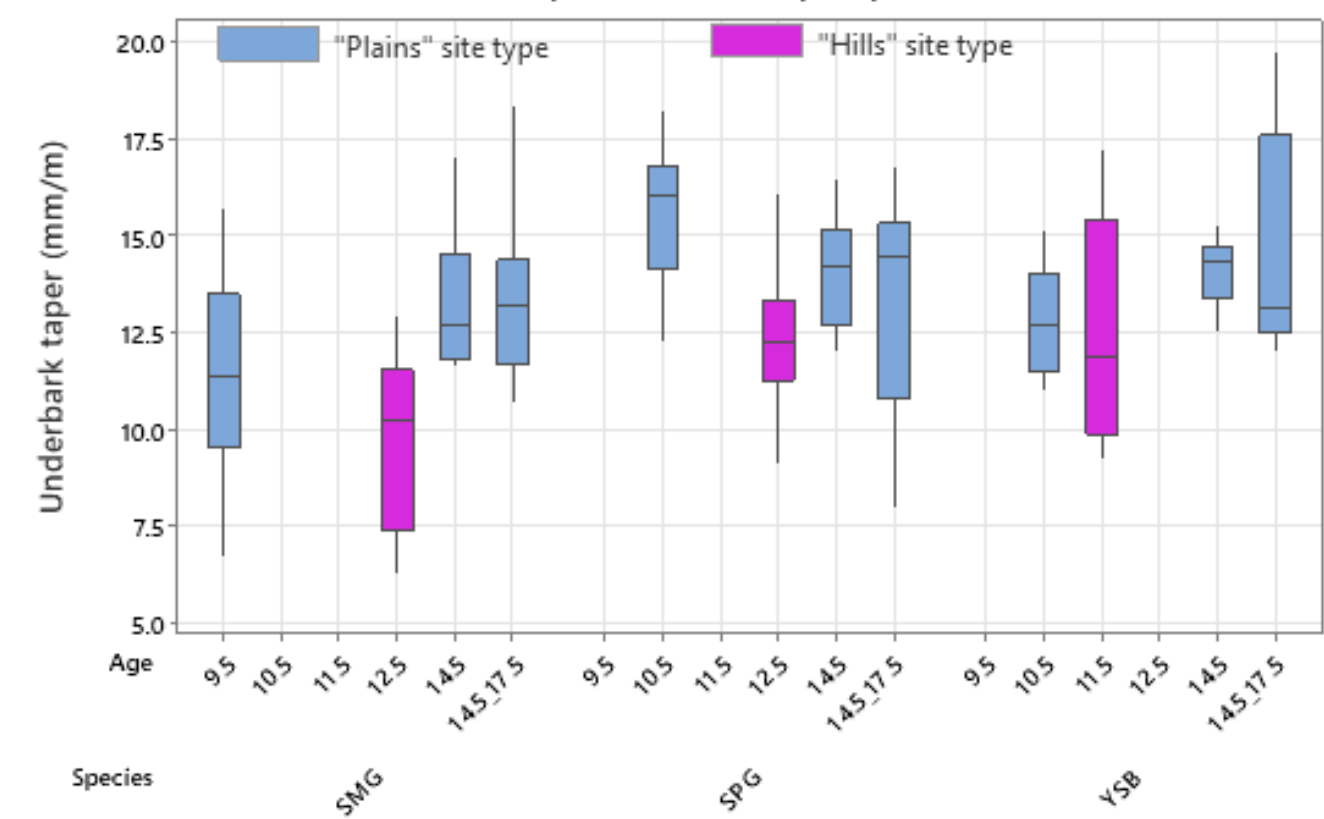
Site ID	Age (yr)	Southern Mahogany	Spotted Gum	Yellow Stringybark
1 (HOL)	9.5	181 (110-279)		
2 (MCM)	10.5		206 (241-274)	229 (129-324)
3 (FIN)	11.5			261 (157-450)
4 (BCK)	12.5	224 (148-358)	219 (155-295)	
5 (MRS)	14.5	257 (167-385)	222 (166-276)	279 (190-434)
6 (ASK)	14.5	300 (226-367)		
6 (ASK)	17.5		274 (147-344)	338 (264-435)





Taper (under-bark)

Underbark taper (mm/m) - per plantation



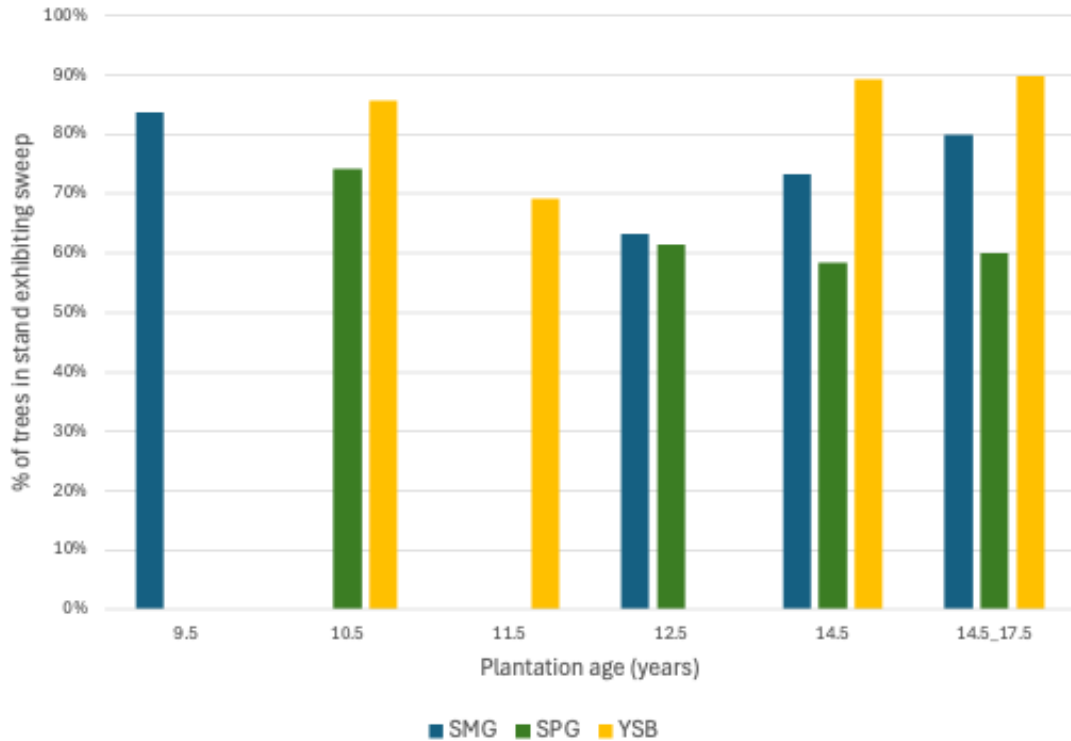
- No significant differences due to age
- Spotted Gum significantly different from Southern Mahogany
- “Hill” sites exhibit significantly lower taper than “plains” sites

Under-bark taper (mm/m) per plantation

Site ID	Age (yr)	Southern Mahogany	Spotted Gum	Yellow Stringybark
1 (HOL)	9.5	11.43		
2 (MCM)	10.5		15.61	12.81
3 (FIN)	11.5			12.51
4 (BCK)	12.5	9.78	12.42	
5 (MRS)	14.5	13.30	14.11	14.06
6 (ASK)	14.5	13.36		
6 (ASK)	17.5		13.18	14.61

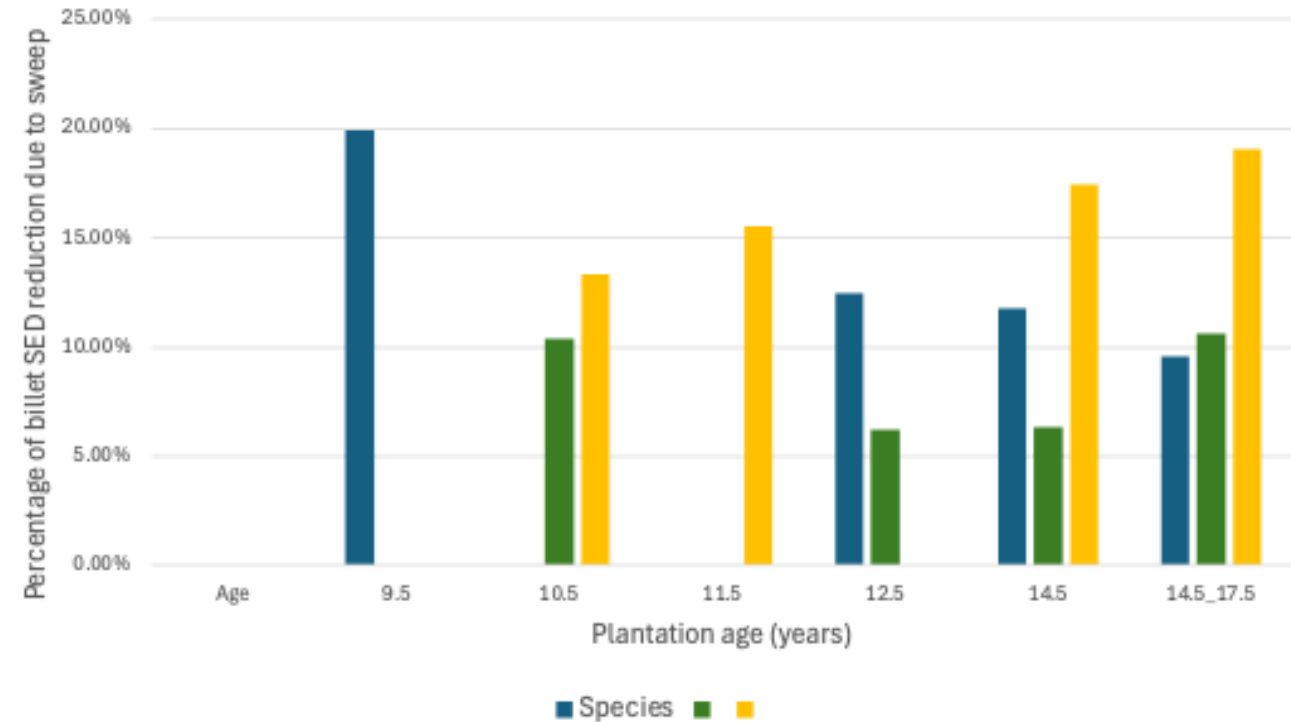
Sweep

Percentage of trees per plantation impacted by sweep



% of stems exhibiting sweep per plantation: 58% – 90%
Yellow Stringybark > Southern Mahogany > Spotted Gum

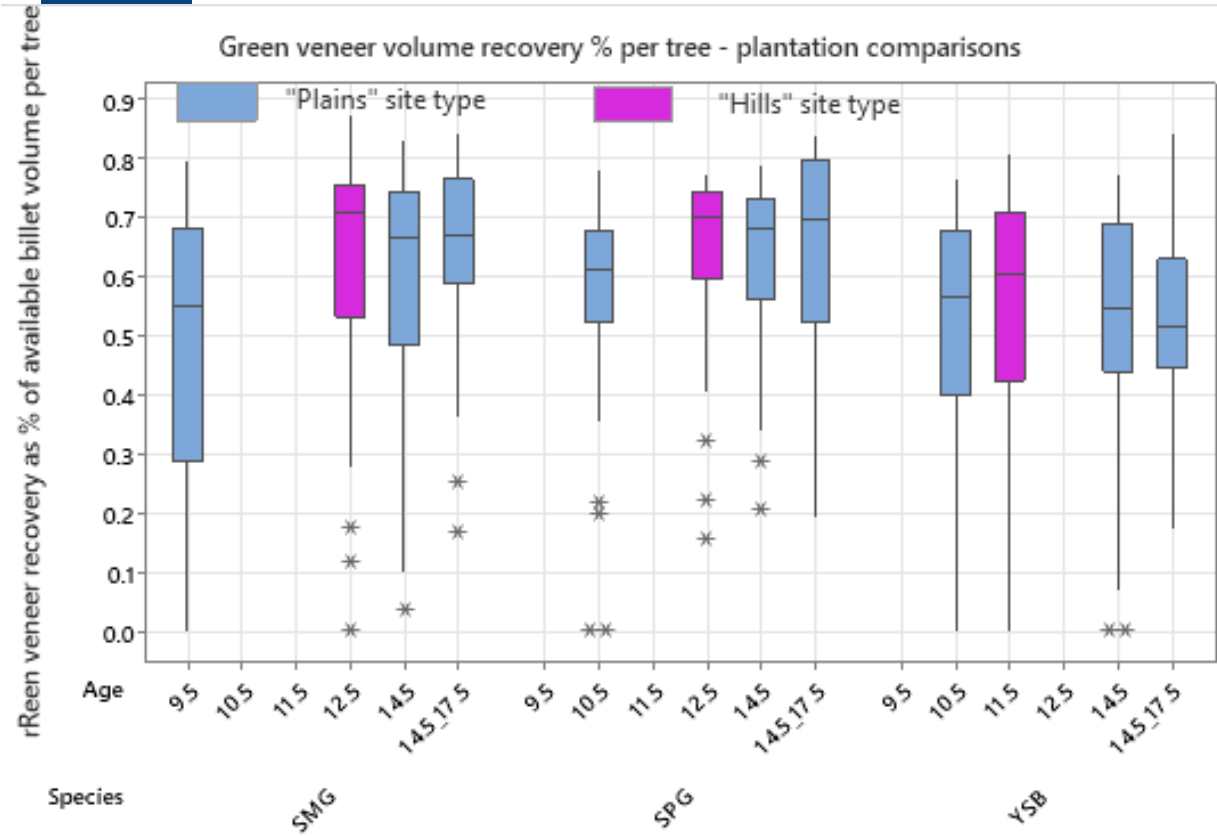
Average % reduction to virtual billet SED due to sweep



Average % reduction to billet SED due to sweep: 6% - 20%
Yellow Stringybark > Southern Mahogany > Spotted Gum



Green veneer volume recovery % per tree



Minimal variation due to age

Spotted Gum (62.75%) > Mahogany (58.5%) > Yellow Stringybark (54%)

Compare to previous studies of log conversion recoveries (international studies 2013-2018: 52-63% recovery; McGavin 2014, 2015: 68 – 77%; NIFPI 2025: 76-82%)

Mean volume m³ per tree x plantation

Site ID	Age (yr)	Southern Mahogany	Spotted Gum	Yellow Stringybark
1 (HOL)	9.5	48%		
2 (MCM)	10.5		56%	53%
3 (FIN)	11.5			56%
4 (BCK)	12.5	63%	66%	
5 (MRS)	14.5	58%	64%	53%
6 (ASK)	14.5	65%		
6 (ASK)	17.5		65%	54%

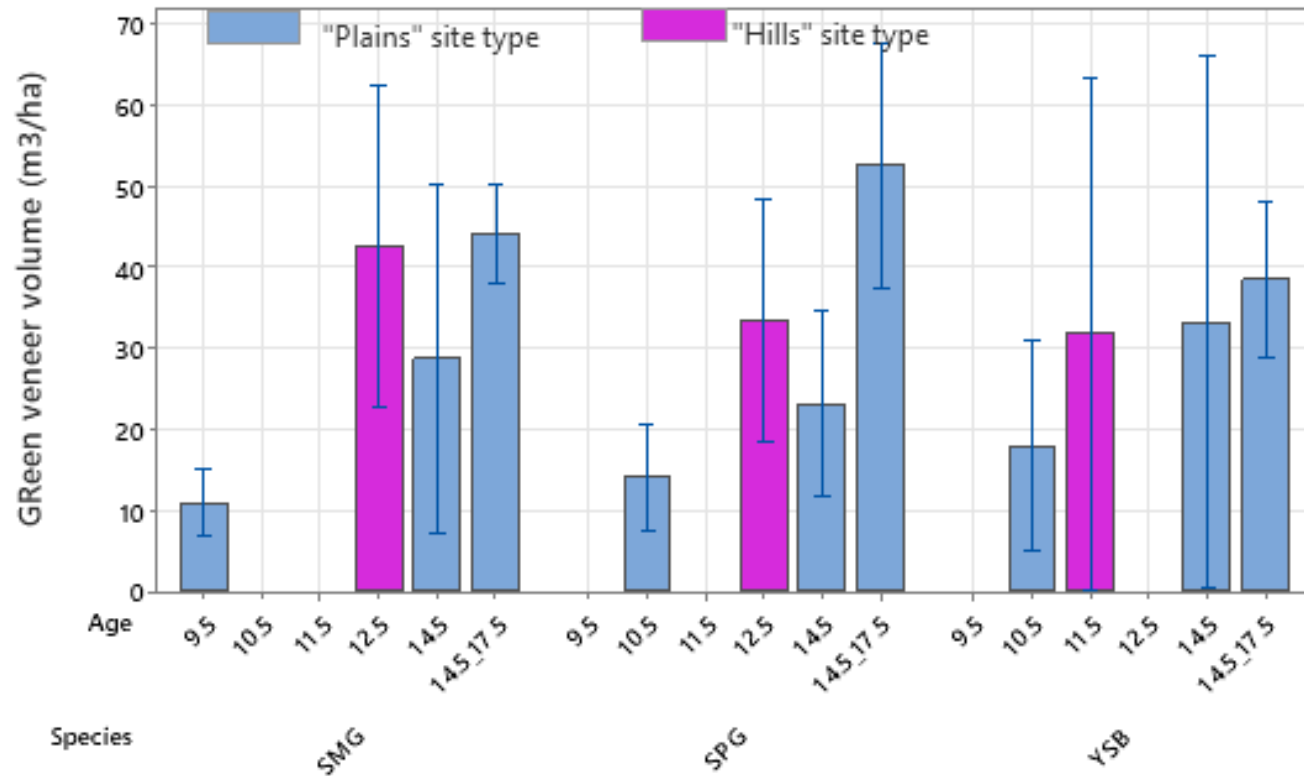
Volume estimations assume: “clear-fall event”

Log length: 2.6m; minimum SED: 100mmç

Green veneer volume per hectare

Volume m³/ha per plantation

Green veneer volume per hectare - plantation comparisons



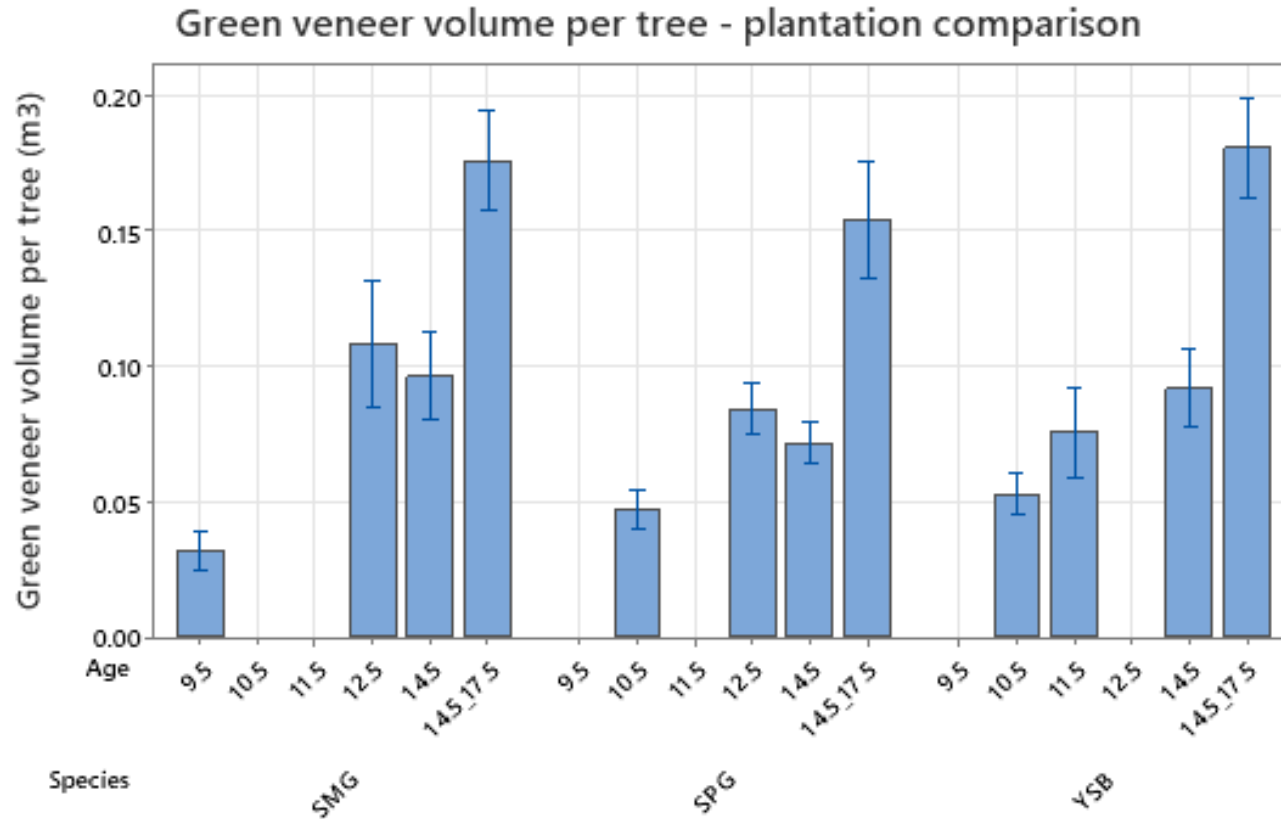
- Age and site type both significant influences
- No significant different due to species (relative species ranking is inconsistent between sites)

Site ID	Age (yr)	Southern Mahogany	Spotted Gum	Yellow Stringybark
1 (HOL)	9.5	10.93		
2 (MCM)	10.5		14.09	18.02
3 (FIN)	11.5			31.89
4 (BCK)	12.5	42.62	33.39	
5 (MRS)	14.5	28.79	23.18	33.26
6 (ASK)	14.5	44.17		
6 (ASK)	17.5		52.59	38.51

Volume estimations assume: **“clear-fall event”**

Log length: 2.6m; minimum **SED:** 100mm

Green veneer volume estimation per tree



Relative ranking of age classes is the same as for per-hectare estimates, but magnitude of difference has changed; the **oldest site is exhibiting larger volumes per tree than younger sites, even where per-hectare volumes are comparable.**

Mean volume m³ per tree x plantation

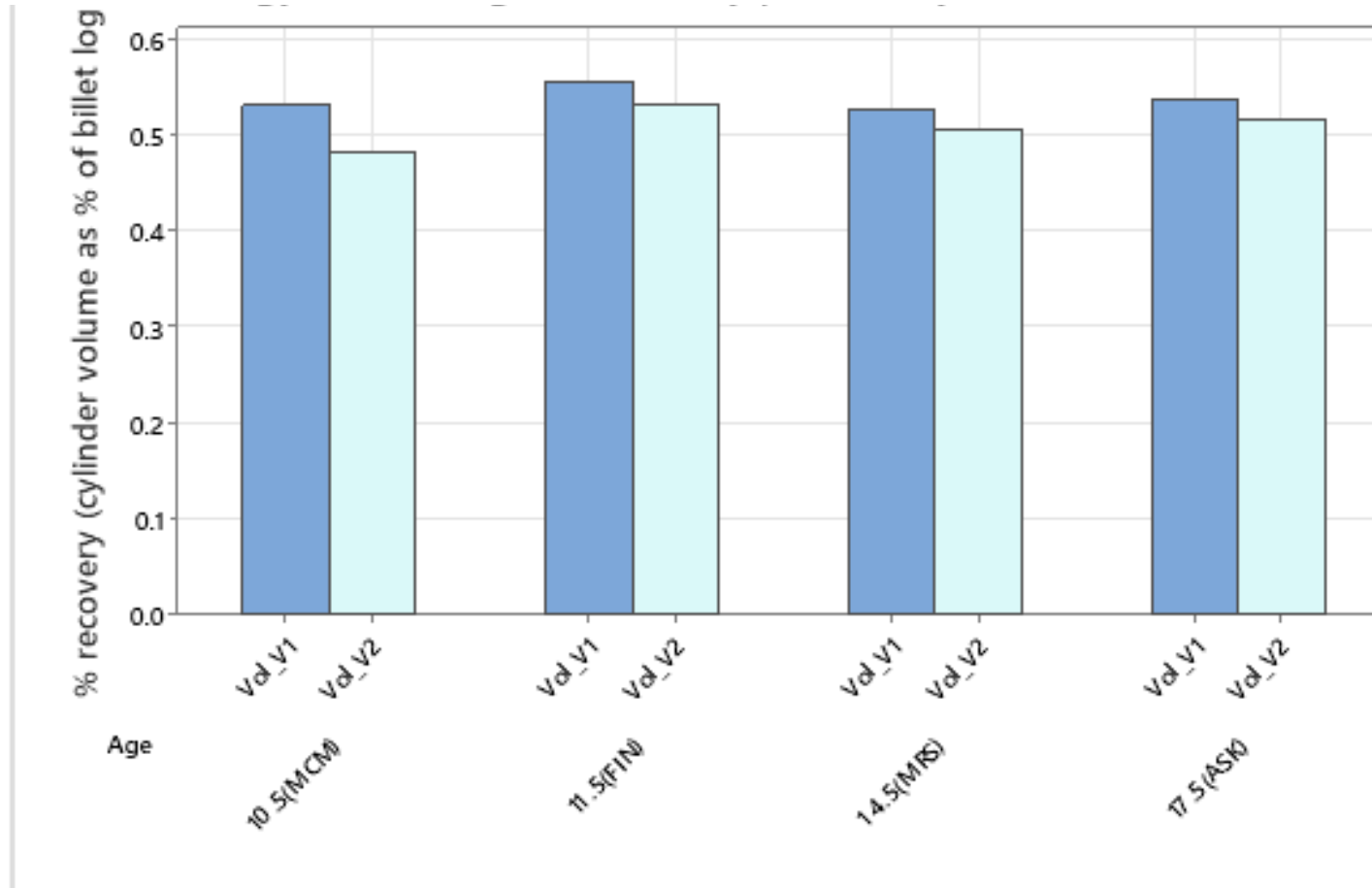
Site ID	Age (yr)	Southern Mahogany	Spotted Gum	Yellow Stringybark
1 (HOL)	9.5	0.0319		
2 (MCM)	10.5		0.0471	0.0530
3 (FIN)	11.5			0.0757
4 (BCK)	12.5	0.1081	0.0844	
5 (MRS)	14.5	0.0964	0.0716	0.0919
6 (ASK)	14.5	0.1759		
6 (ASK)	17.5		0.1541	0.1806

Volume estimations assume: “clear-fall event”

Log length: 2.6m; minimum SED: 100mmç

Screening for sweep at the rounding lathe

% volume recovery per tree if billets excluded at sweep screening at lathe
(Yellow Stringybark)



Minimal impact to volume recovery at lathe if billets are excluded that no longer meet SED requirements after a screening at the rounding lathe.

Additional analyses TBA: impact to overall volume production per hectare of sweep screening.

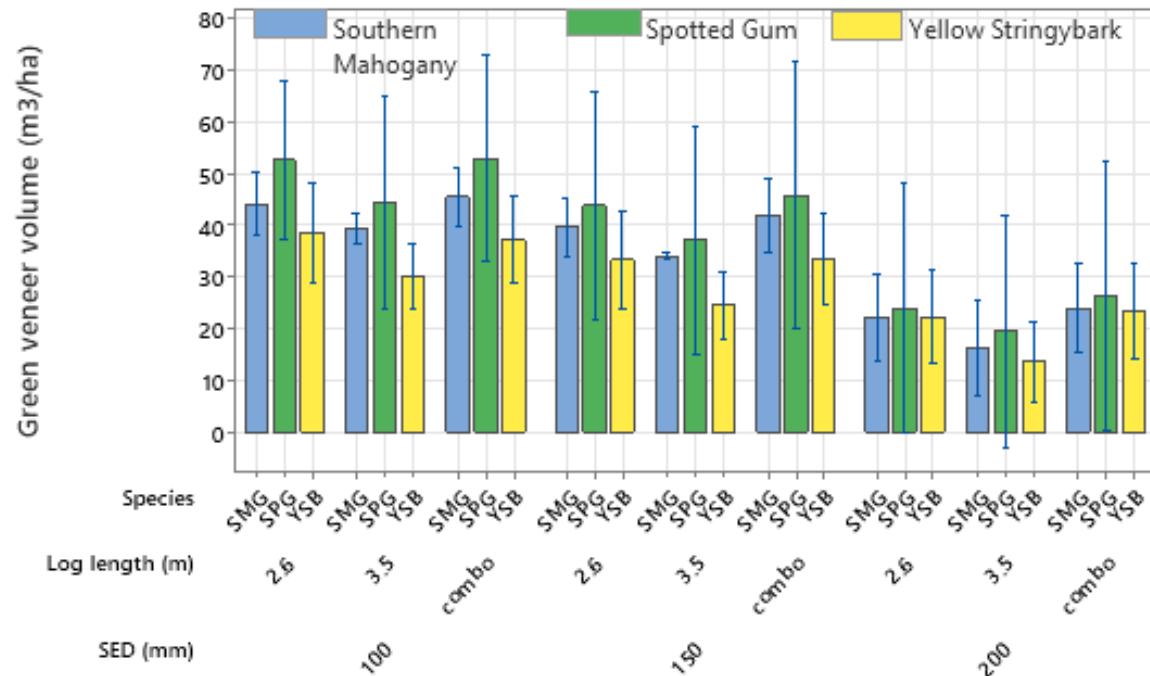
Green veneer volume per ha x 9 log dimension scenarios

3 SED scenarios: 100mm, 150mm, 200mm

3 long length scenarios: 2.6m, 3.5m, combination

Oldest spotted gum site (17.5y - ASK)

Green veneer volume per hectare (17.5yo site - ASK)



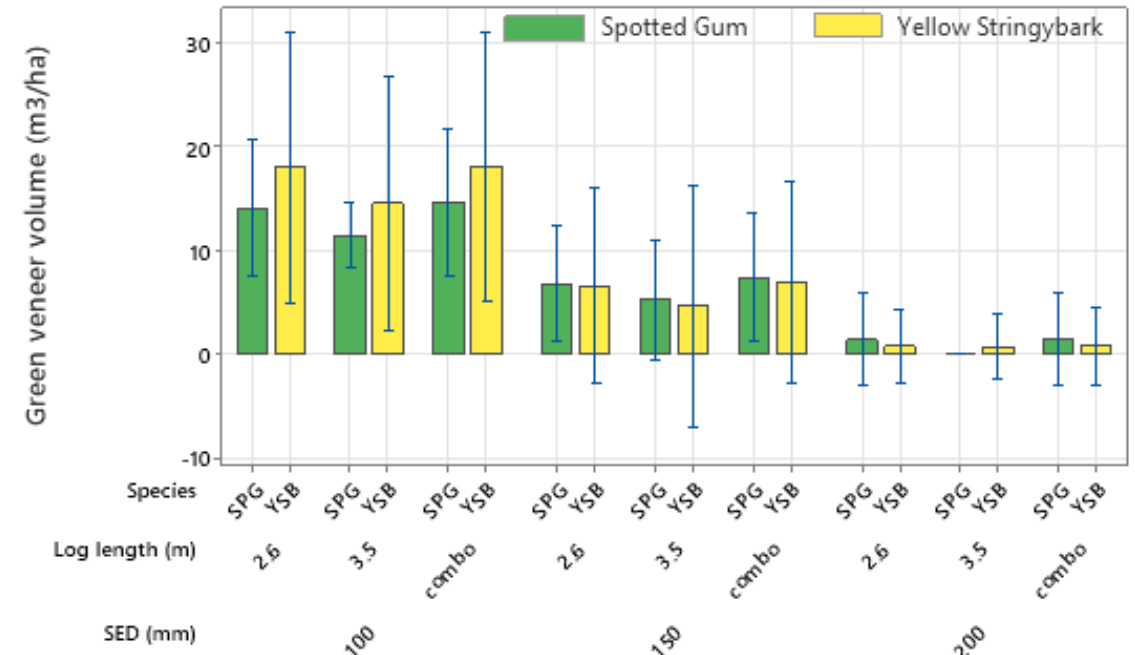
ASK spotted gum volume estimate range (m³/ha):

Max: 52.9 m³/ha (SED 100mm, combo log length)

Min: 19.53 m³/ha (SED 200mm, 3.5m log length)

Youngest spotted gum site (10.5 - MCM)

Green veneer volume per hectare (10.5yo site - MCM)



MCM spotted gum volume estimate range (m³/ha):

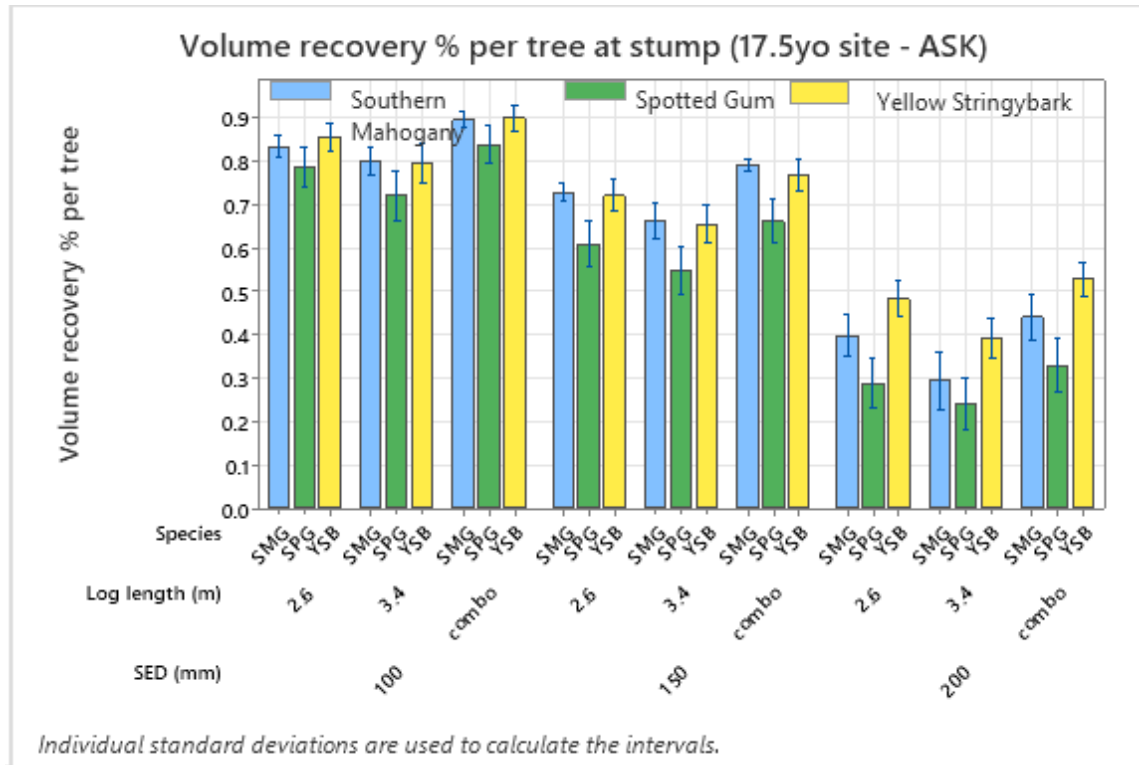
Max: 14.69 m³/ha (SED 100mm, combo log length)

Min: 0 m³/ha (SED 200mm, 3.5m log length)

Green veneer recovery % per tree x 9 log dimension scenarios

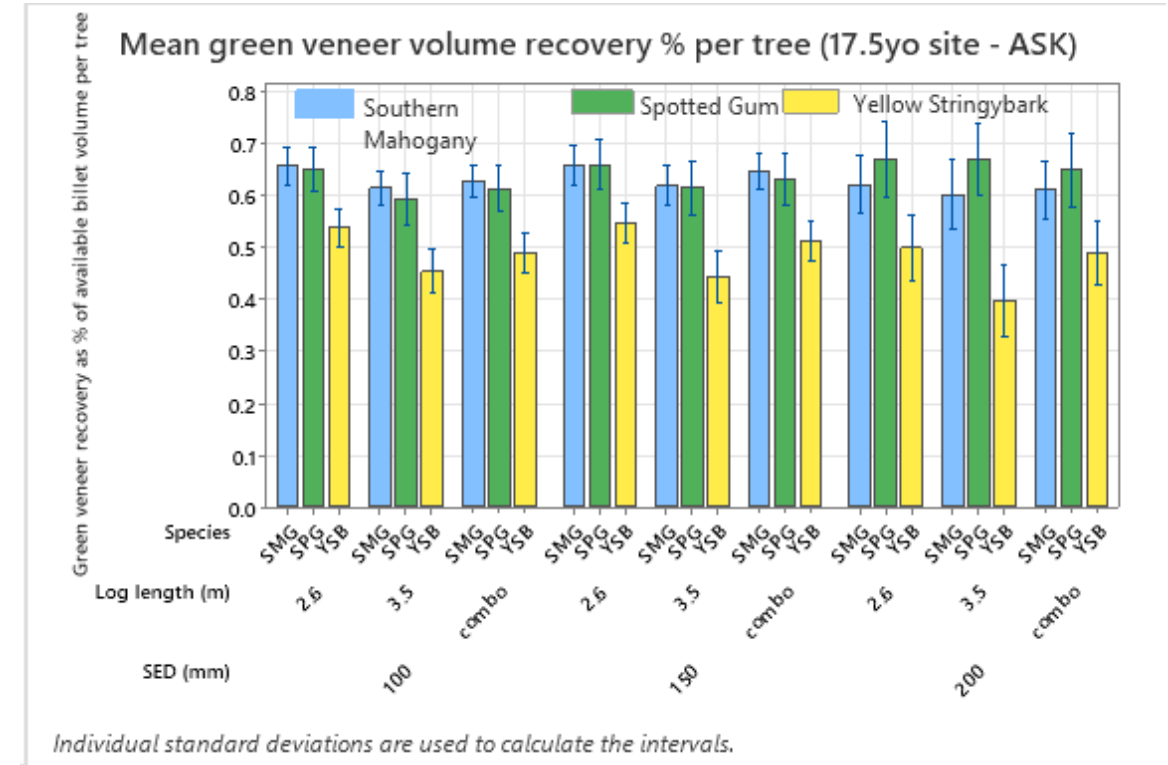
“At stump” recovery Vs “at lathe” recovery

Recovery “at stump”



Recovery per tree “at stump” declines as SED threshold increases

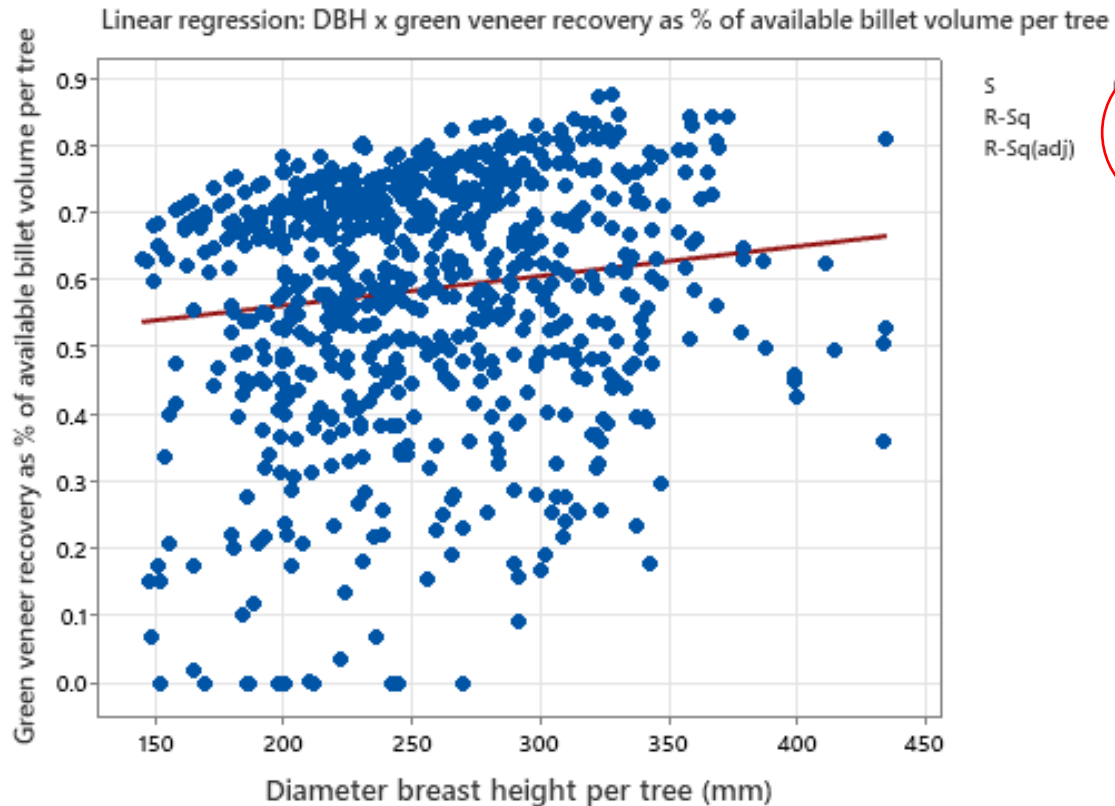
Recovery “at lathe”



Recovery per tree “at lathe” varies little with changes to SED threshold

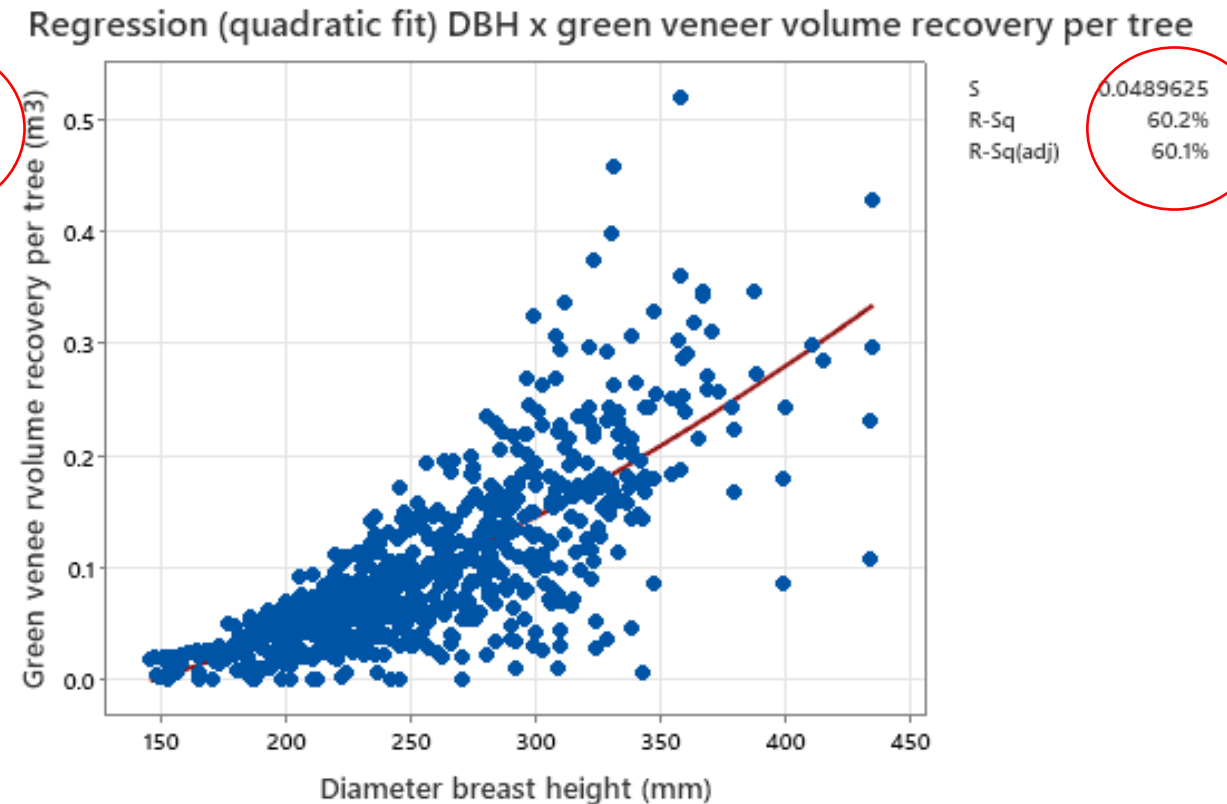
Correlating DBH with per-tree volume estimates

DBH x volume % recovery per tree



Not useful for threshold modelling!

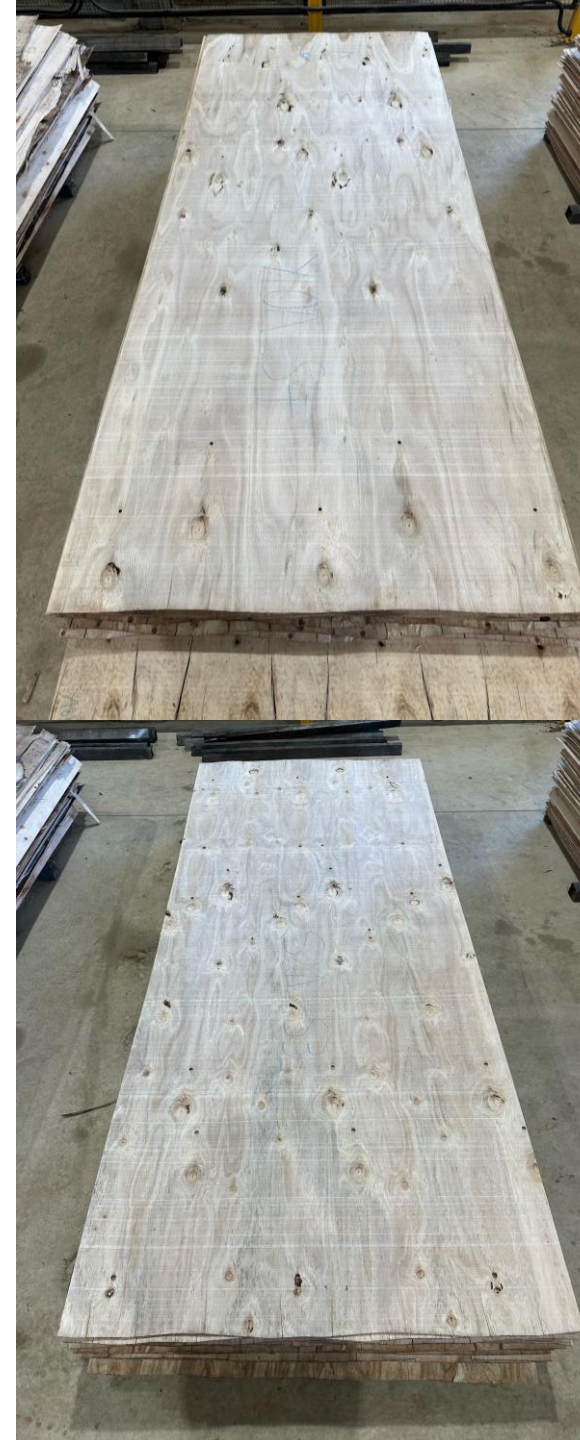
DBH x volume (m3) per tree



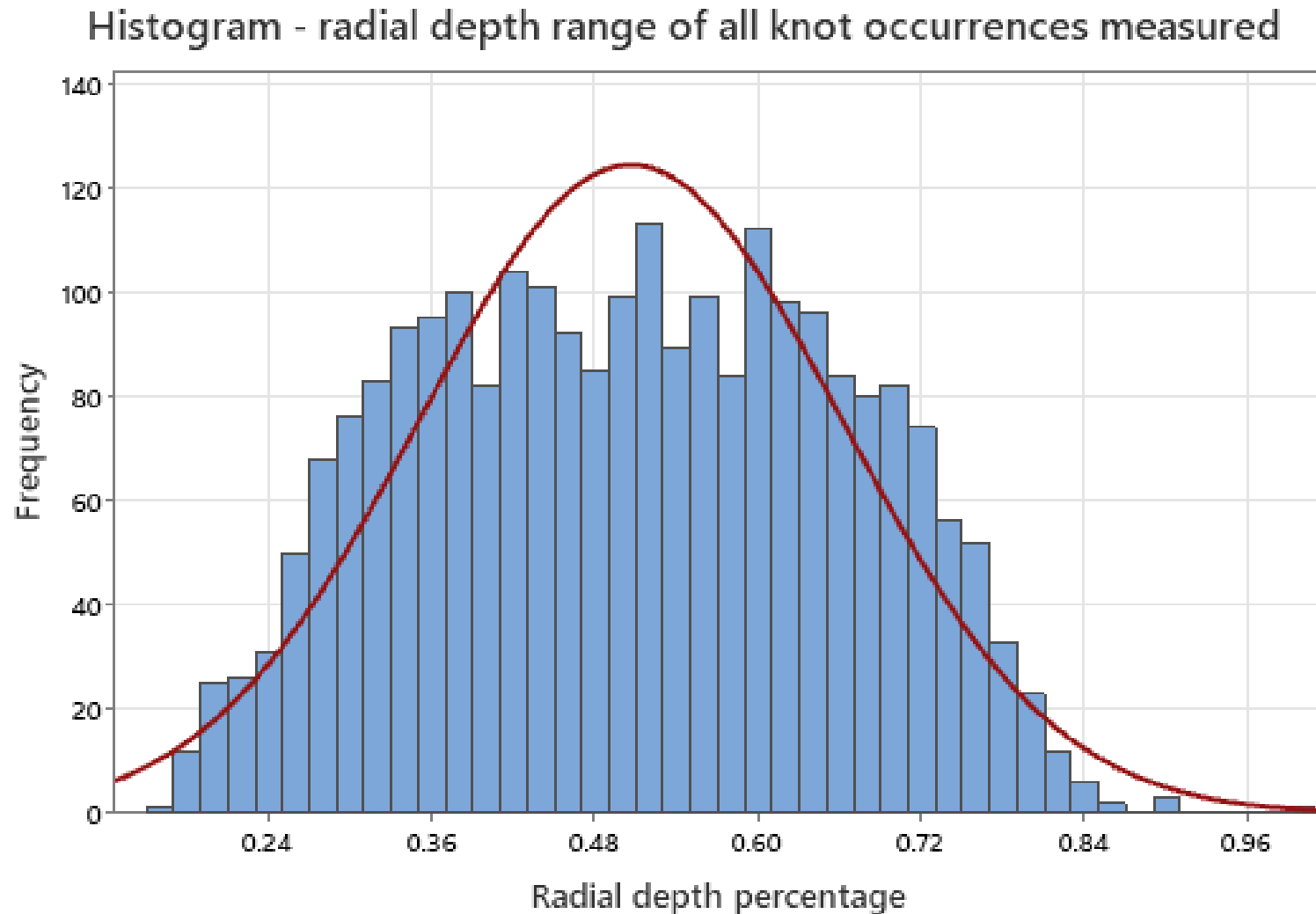
Useful for developing predictive models of DBH- volume thresholds

Knot width analysis

- Correlation analysis using linear regression and scatter plots
 - Knot width $\sim$ radial depth association
 - Knot width $\sim$ branch diameter association
 - Knot width $\sim$ branch angle association
- Linear mixed models to:
 - Assess significance of correlations
 - Estimate branch diameter and angle thresholds of acceptability that correspond with knot width thresholds from the grading standard

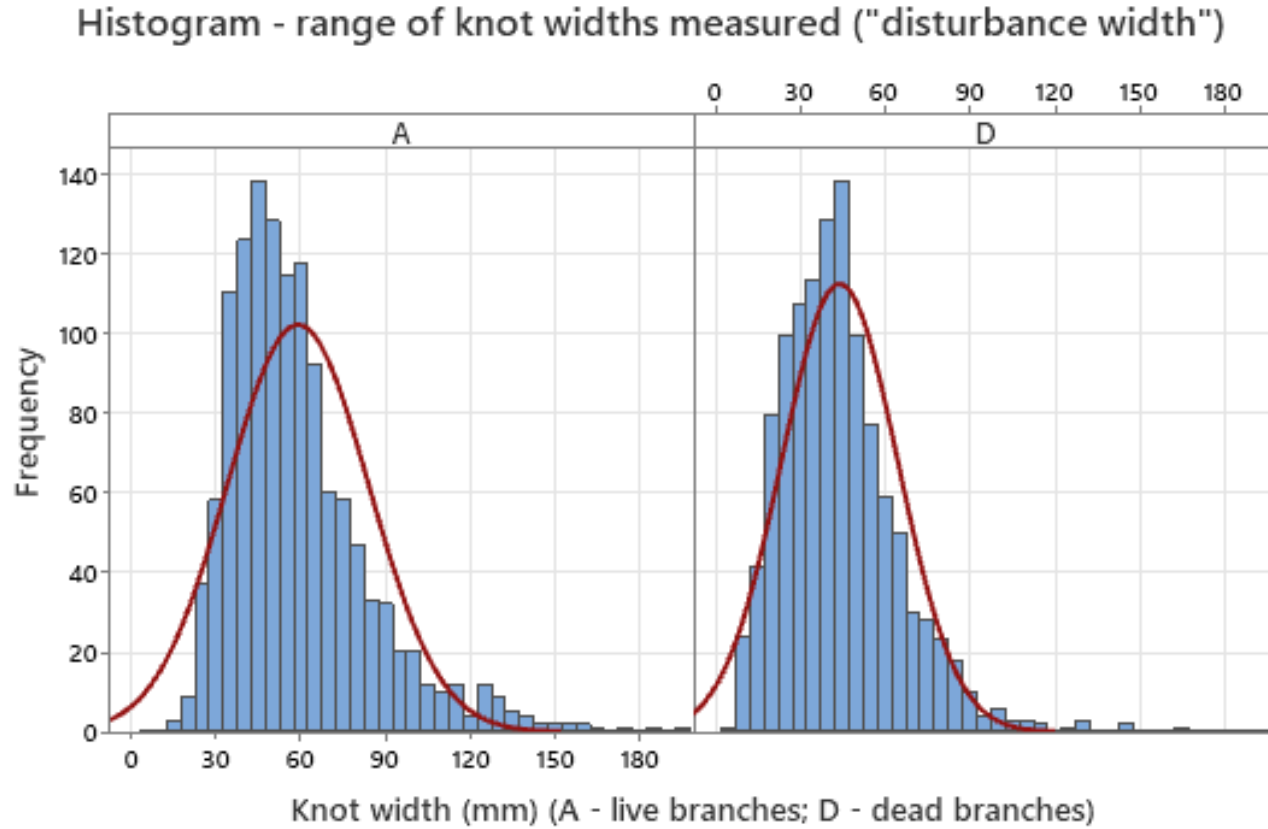


Radial depth sampling profile



Samples size tapers off below 30% and above 70% radial depth

Knot width range sampled (“disturbance width”)



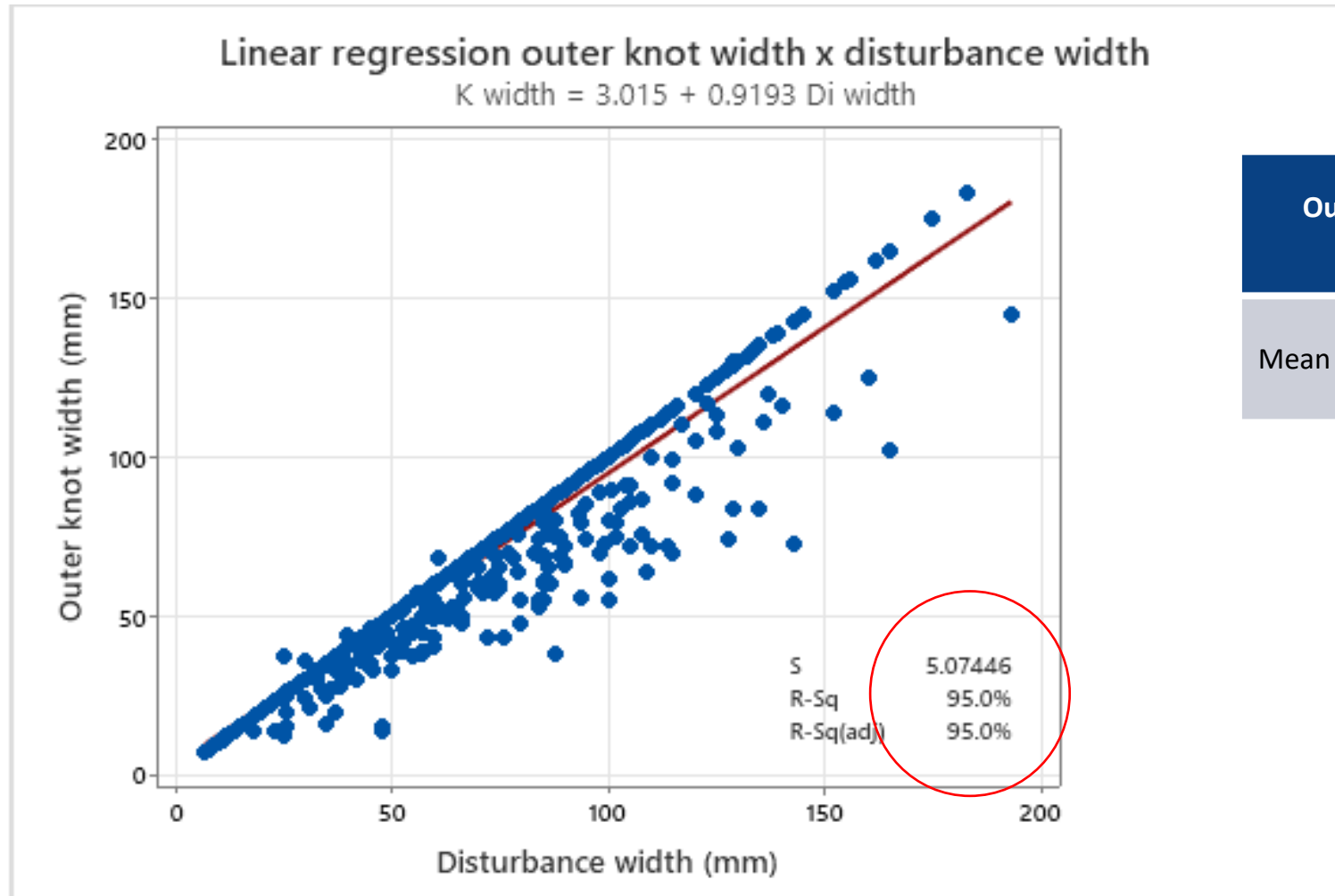
Panel variable: Revised Live Status

Knot width statistic (mm)	Live branches	Dead branches
Mean	59	44
Minimum	13	7
Maximum	193	165

Grading standard thresholds range from 4mm – 75mm knot width.

Sample size tapers off below 20-30mm and above 50-60mm

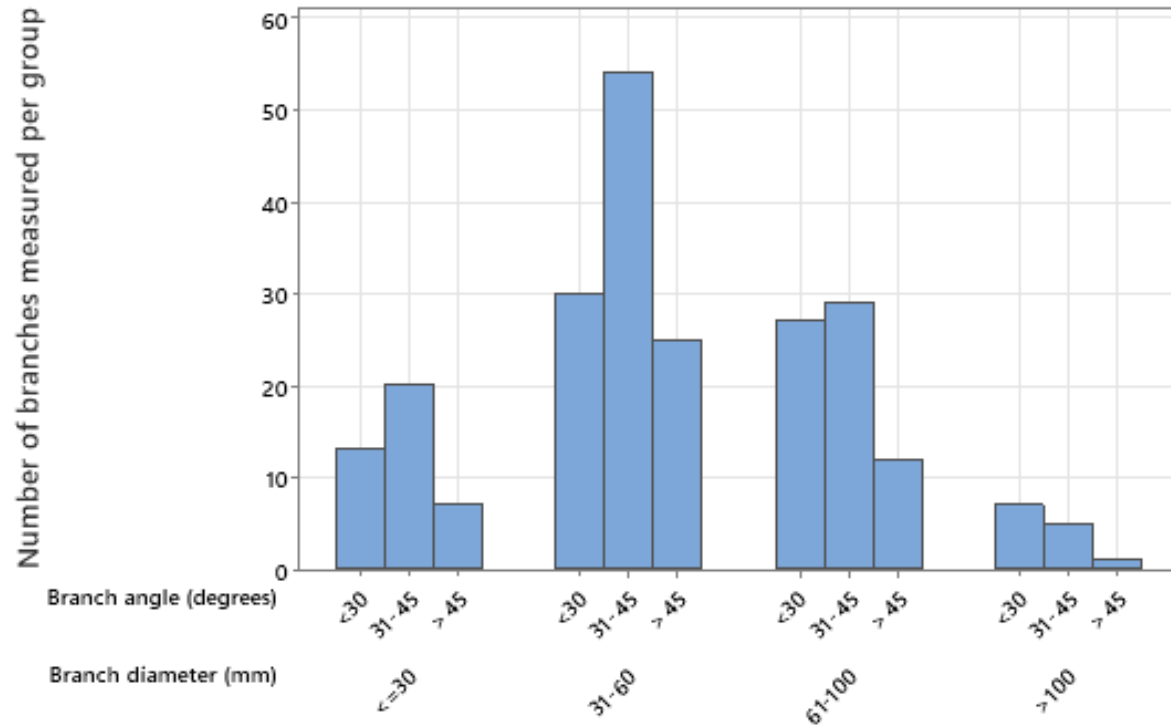
“Disturbance width” as a proxy for “outer knot width”



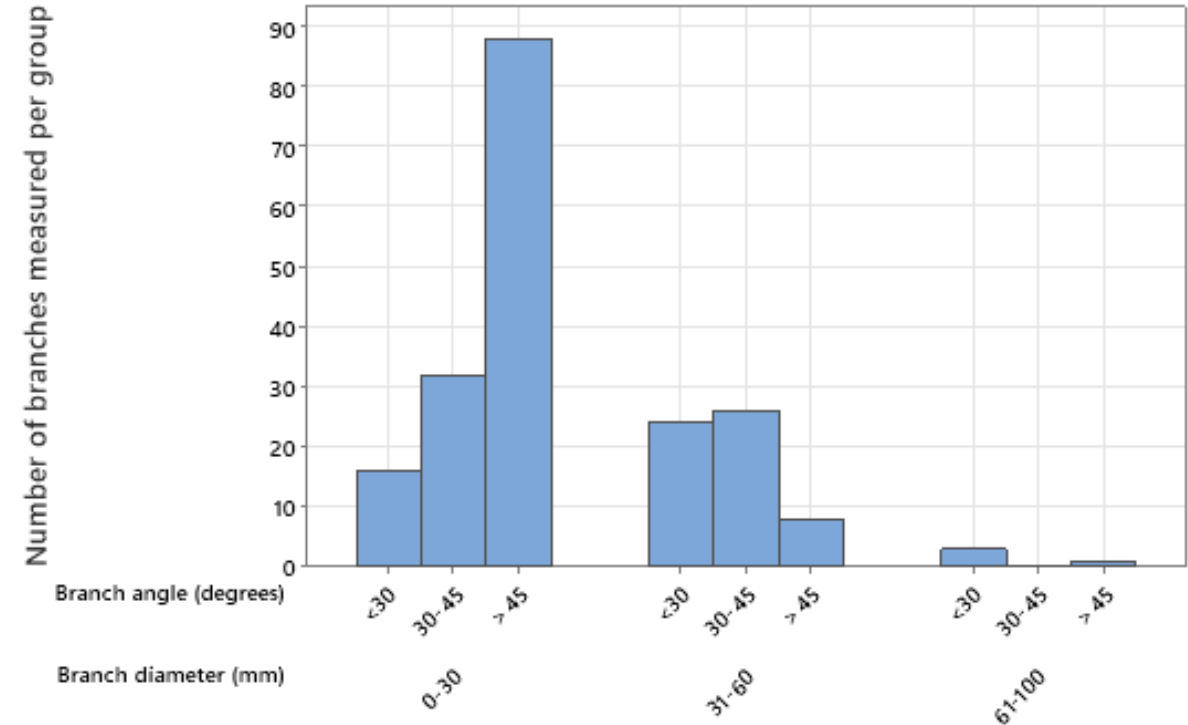
Outer knot width as % of disturbance width	Live branches	Dead branches
Mean	99%	98%

Branch & knot sample summary

Sample size per branch type group (live branches)



Sample size per branch type group (dead branches)



Total branches sampled: 428 (live – 230, dead – 198); **log centre diameters** ranged from 133 – 274mm

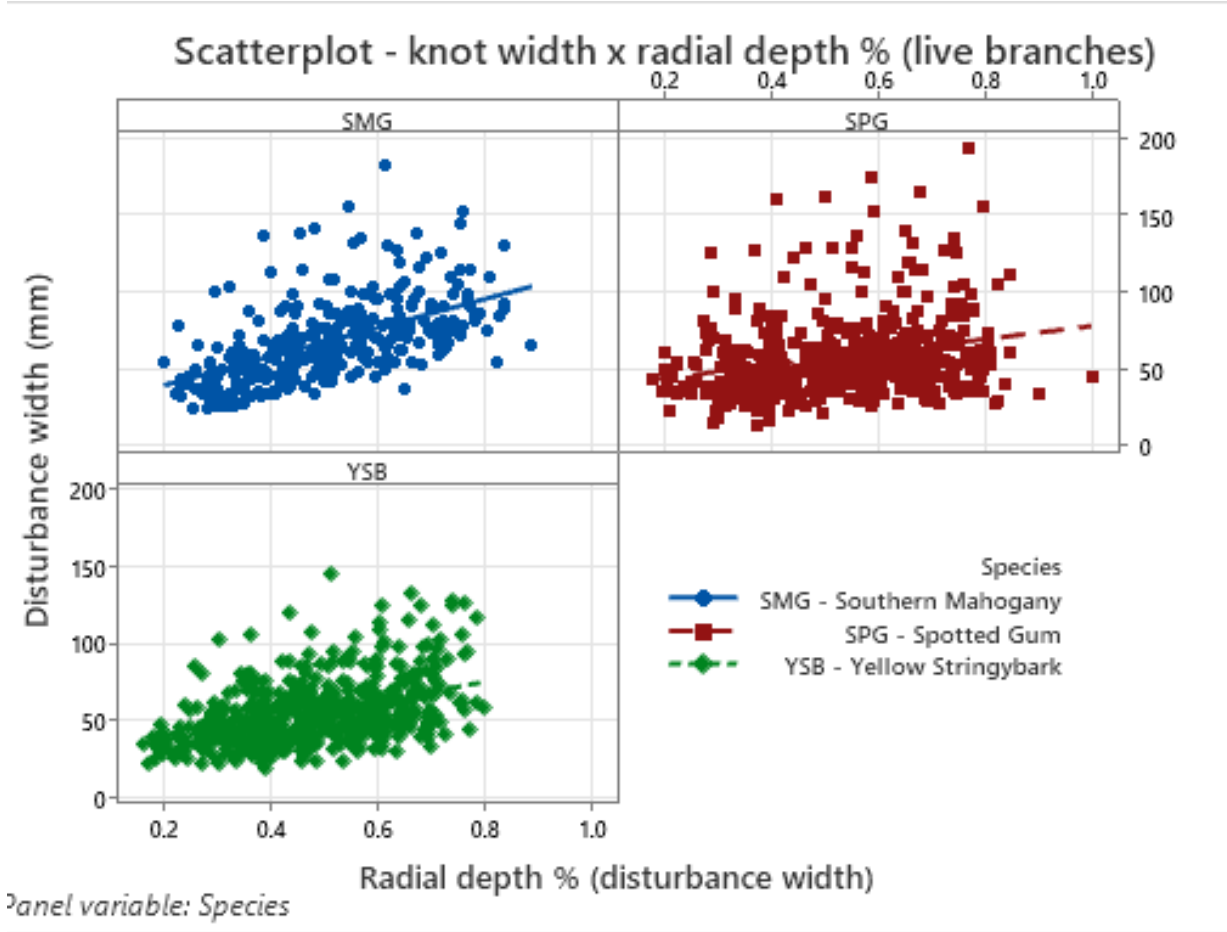
Branches sampled per species: 170 - Yellow Stringybark; 151 – Spotted Gum; 107 – Southern Mahogany

Knot sample **radial depth range** within logs: 16 – 99% (majority between 30 – 70%)

Knot width range: 13 – 193mm (live branches); 7 – 165mm (dead branches).

Correlation of knot (disturbance) width to radial depth

Does knot width change for different radial depths from pith to bark?



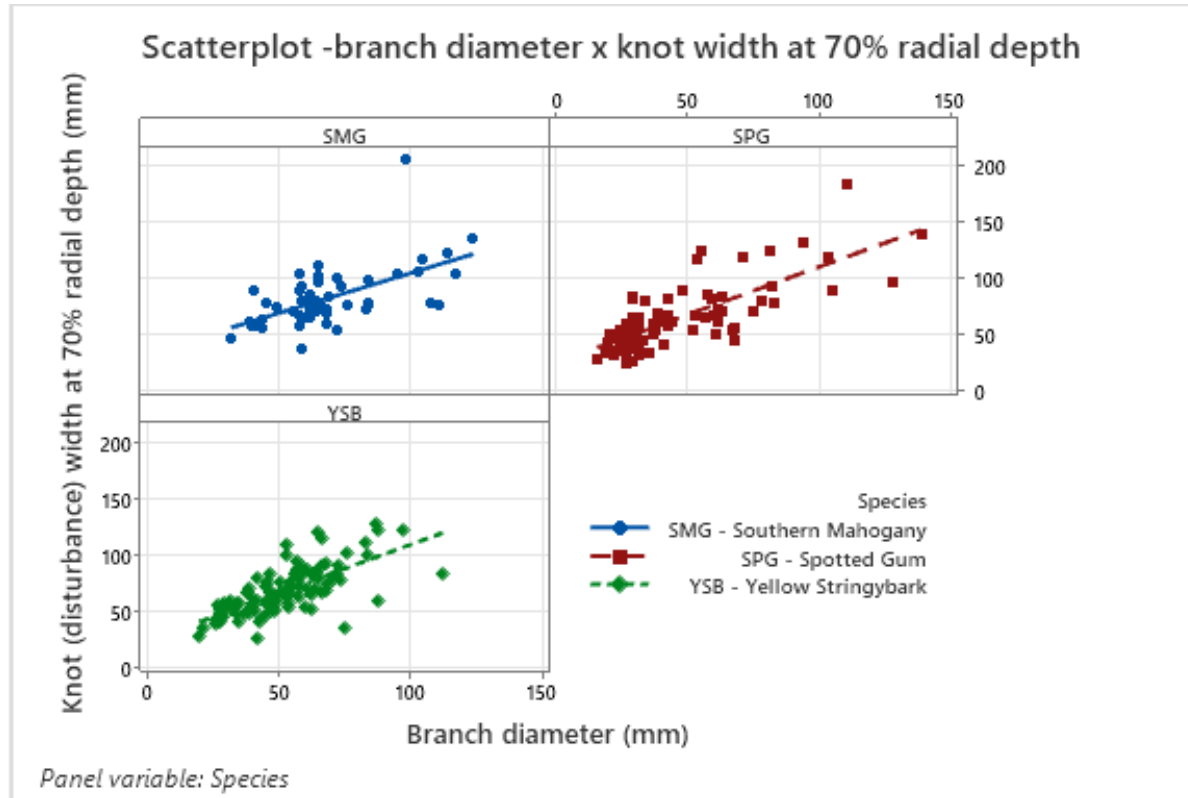
Pearson’s correlation coefficients

Branch Group	Live	Dead
All species	0.390	0.226
Southern Mahogany	0.542	0.453
Spotted Gum	0.261	0.118
Yellow Stringybark	0.438	0.212

Correlations sufficiently different for each species to treat species groups separately in subsequent analysis of branch – knot relationships. Correlations strong enough to assume knot width tapers with radial depth.

Correlation of branch diameter to knot width

Correlates branch diameter to knot width estimate at 70% radial depth



Pearson's correlation coefficients

Branch Group	Live	Dead
All species	0.728	0.786
Southern Mahogany	0.584	0.769
Spotted Gum	0.759	0.880
Yellow Stringybark	0.706	0.654

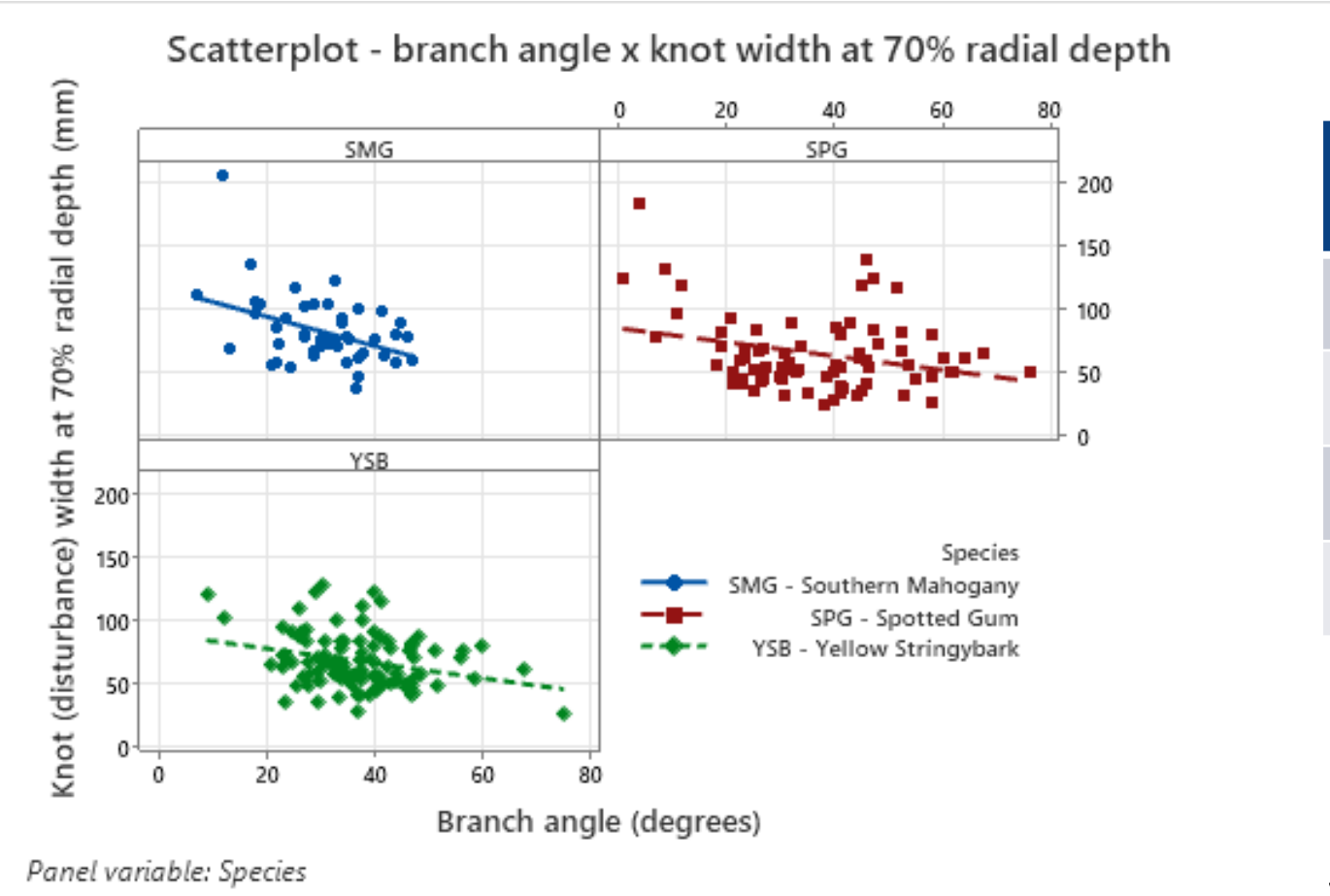
Correlations are strong for all branch groups.

This suggests a model can be developed to predict knot width for a given branch diameter at a given radial depth



Correlation of branch angle to knot width

Correlates branch angle (from the vertical) to knot width at 70% radial depth



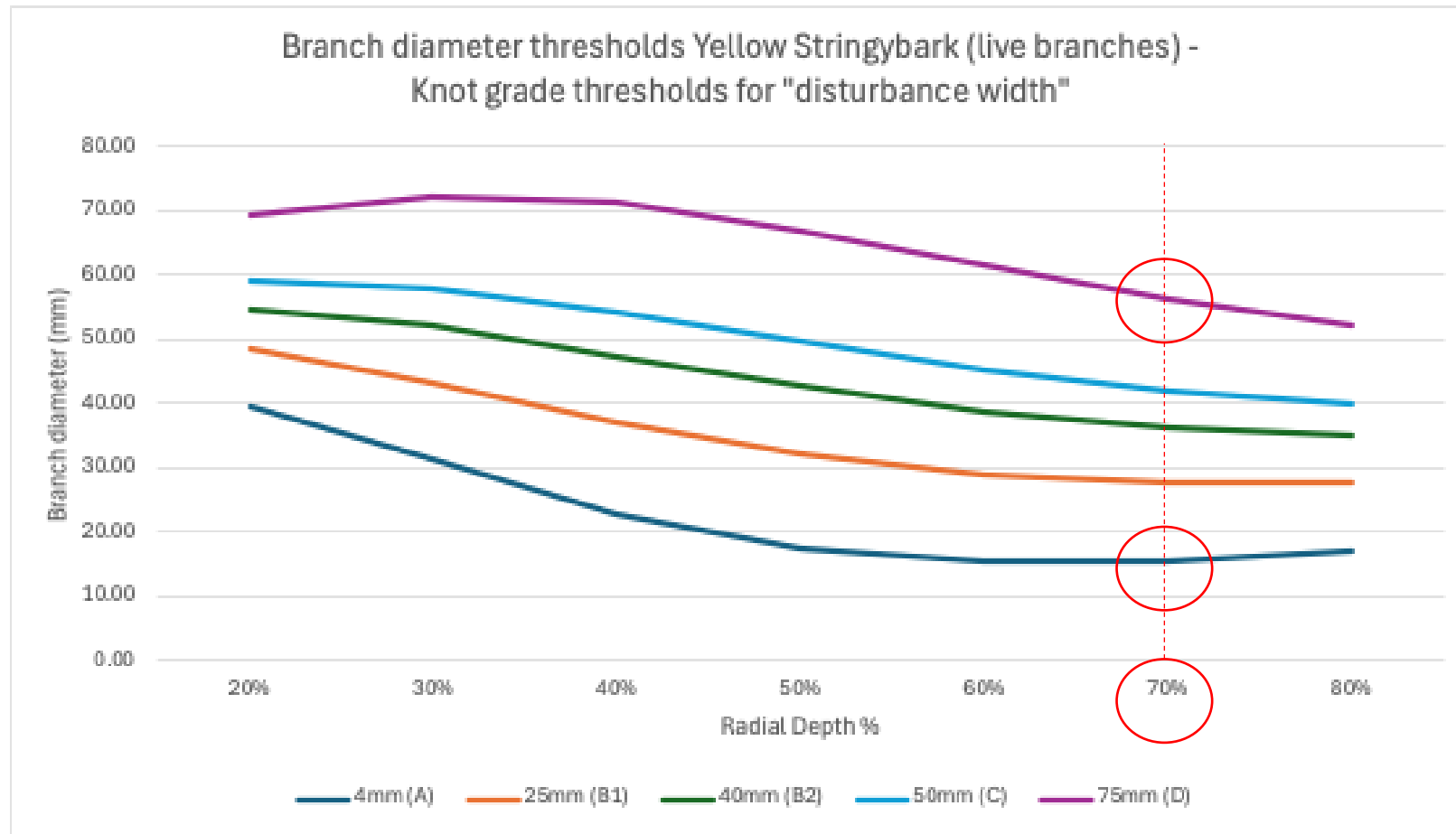
Pearson's correlation coefficients

Branch Group	Live	Dead
All species	0.352	0.599
Southern Mahogany	0.410	0.351
Spotted Gum	0.292	0.660
Yellow Stringybark	0.286	0.555

Correlations are moderate – with knot width decreasing as branch angle increases.

Development of a model that predicts knot width for a given branch diameter is warranted.

Estimating branch diameter thresholds (comparing knot width thresholds at different radial depths)



- Assuming that knot width decreases closer to the core, branch tolerances increase for radial depths closer to core. This does NOT take into account increasing frequency of occurrence of knots in the veneer ribbon as the log diameter reduces closer to the core.
- Knot related defects can increase closer to core for large branches – thresholds for larger branches can plateau or decline

Estimating branch diameter thresholds (rounding up to nearest 10mm for practical application)

Example: Yellow Stringybark live branches

Knot width threshold	Branch diameter threshold (rounded up) per radial depth %						
	20%	30%	40%	50%	60%	70%	80%
4mm (A)	40	40	30	20	20	20	20
25mm (B1)	50	50	40	40	30	30	30
40mm (B2)	60	60	50	50	40	40	40
50mm (C)	60	60	60	50	50	50	40
75mm (D)	70	80	80	70	70	60	60

Example: all branch groups at 70% radial depth

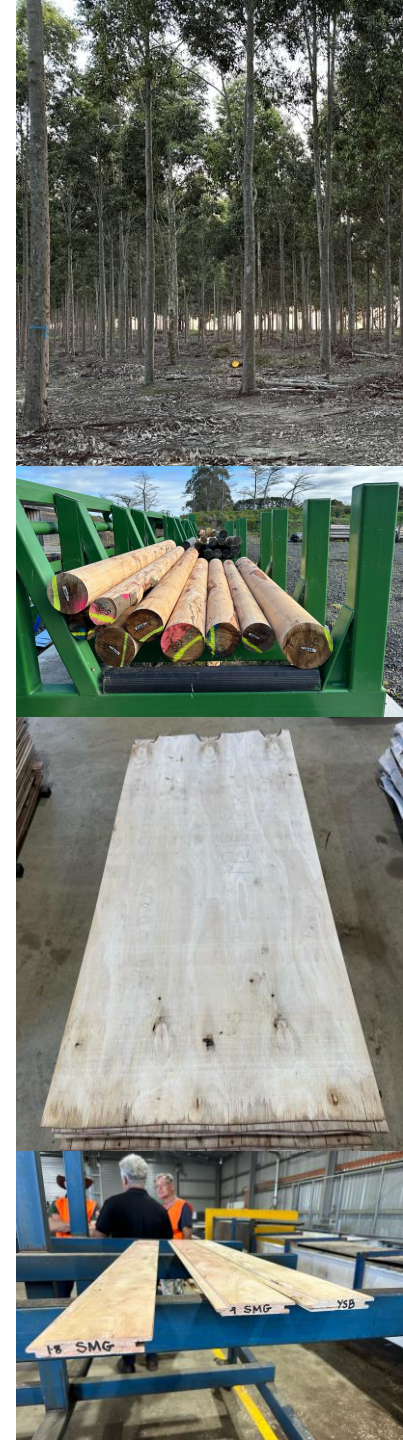
Knot width threshold	Branch diameter at 70% radial depth per group - DISTURBANCE WIDTH					
	SMG A	SPG A	YSB A	SMG D	SPG D	YSB D
4mm (A)	40	20	20	10	10	10
25mm (B1)	50	30	30	20	20	20
40mm (B2)	60	40	40	30	20	30
50mm (C)	60	50	50	40	30	30
75mm (D)	70	60	60	50	40	40

- What is the practical difference between thresholds at different radial depths or branch groups?
- What is the impact of rounding up vs rounding down (~ 10mm reduction)
- How do these thresholds compare to protocol previously applied in some Qld studies?
 - Live branches <=60mm
 - Dead branches <=30mm

Applying this study in practice

This study allows us to be better able to:

- **Predict** expected peeler log **volume outputs** for Gippsland hardwood plantation types
- **Identify plantation management choices** that could optimize plantation suitability for peeler log production
- Predict veneer volume and quality outputs for different **geometry based utilisation scenarios**
- **Confirm** how tree, log and branch **geometry influences veneer volume and quality**
- Develop geometry-based **thresholds of acceptability** for tree, log and branch specifications
- **Next step:** economic study to define **commercially acceptable thresholds of production** that can help identify visually observable thresholds of acceptability for tree, log and branch specifications (eg DBH, branch diameter/ angle, sweep severity)





Limitations and further research

Log geometry/ volume study – limitations:

- Subjective sweep & defect assessment method
- Assumption of linear tree taper
- Imbalanced representation of plantation types
- Extent of analysis limited by basic modelling tool

Log geometry/ volume study – further research:

- More comprehensive analysis of how sweep defect impacts peeler log volume production – including alternative methods of measurement and modelling
- Assess wider range of plantation types (species, more “hill” sites, different management regimes)
- Economic and market analyses to help define commercial volume production thresholds of acceptability – how much is enough?

Branch/ knot study - limitations

- Subjective knot measurement method
- Assumption of linear knot width taper by radial depth
- Minimal sampling at extremities of knot and branch width range
- Sampling extent reduced by practical/cost limits

Branch/ knot study - further research

- Assess knot related defect severity (soundness, knot holes, decay, bark & kino pockets)
- Assess relationship between knot frequency of occurrence & log diameter (cumulative defect)
- Comprehensive measure of branch type frequency of occurrence in Gippsland hardwood plantation estate – to assess branch severity of different plantations

Thankyou!

- My supervisors: **Dr Robert McGavin**, **Dr Benoit Belleville** and **Professor Rod Keenan**
- Chris McEvoy, Tony Britton and many of the **Radial Timbers** team (plantation inventory, harvesting, peeling and veneer measures)
- **QDPI team** (for teaching a forest grower how to measure veneer and talk “wood!”)
- **Heartwood Unlimited**, especially Cam Fowler (plantation inventory)
- **Incite Silviculture** team, especially Paul McKnight (destructive taper & branch sampling)
- **Seb Klein** (fellow student and brainstormer)
- **Graham Hepworth** (UoM stats advisor)
- **NIFPI steering committee**

