Product-driven eucalypt-fibre selection for papermaking

by
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Product-driven eucalypt-fibre selection for papermaking

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1. Bleached eucalypt market kraft fibres and end-use suitabilities

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Hardwood fibre types

Eucalypt

Acacia

Birch / Aspen / Poplar

Mixed hardwood

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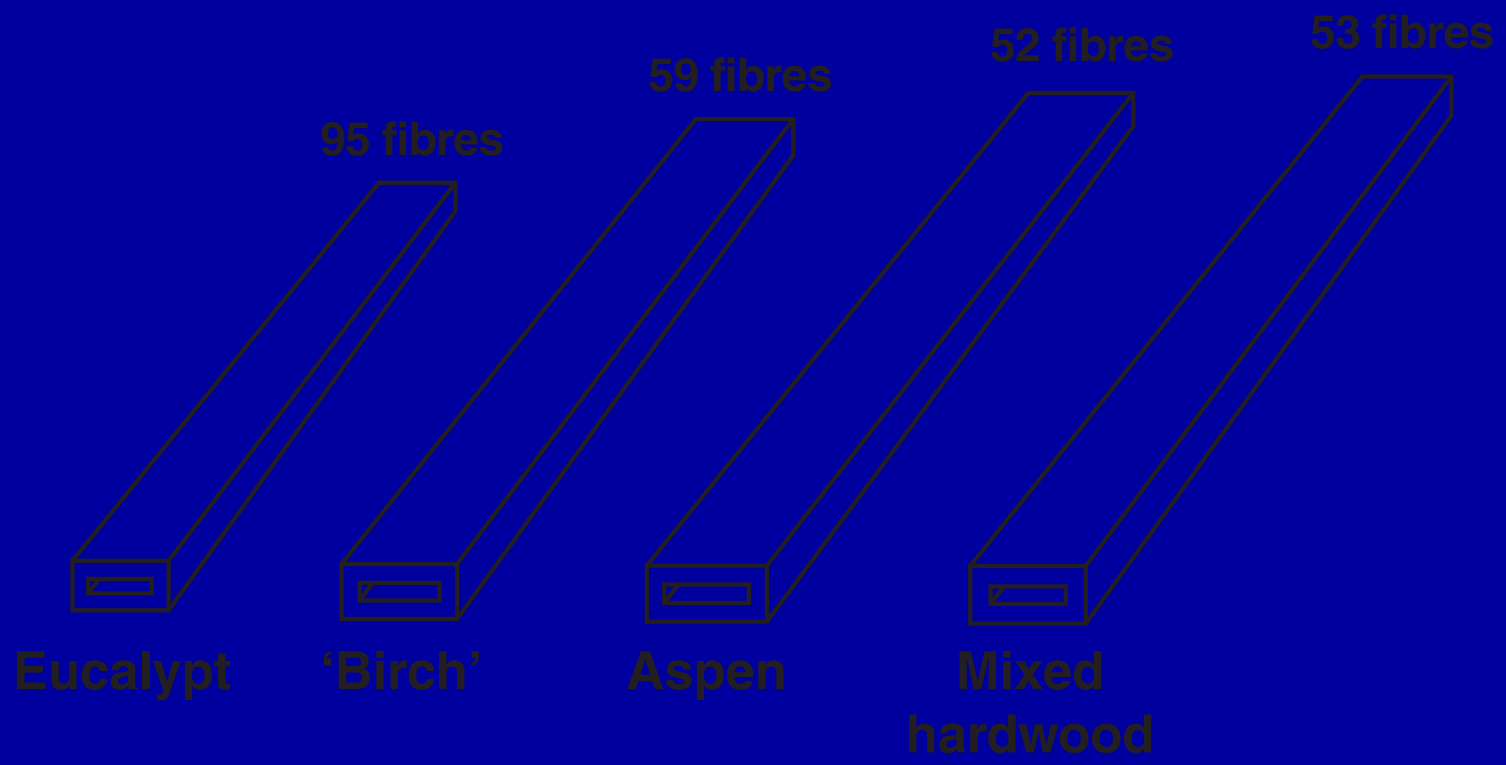
Hardwood market kraft types



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Eucalypt fibres	Birch/Poplar fibres
Short	Long
Slender	Broad
Thin to thick walls	Thin walls
Low coarseness	High coarseness
Large numbers	Small numbers
⇩	⇩
Kraft pulp component in papers	Mechanical pulp component in papers

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No fixed rules to follow!!

Nothing set-in concrete!!

Exceptions to a rule always occur!!

For example

Eucalyptus regnans !!

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For a eucalypt

E. regnans

Low density with broad and thin walled fibres

Mediocre kraft pulp at mature age

Good CTMP pulp at young age

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Globulus versus Regnans

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Categories of eucalypt market kraft pulp

- High bulk (B)
- Intermediate bulk (A)
- *Eucalyptus regnans*

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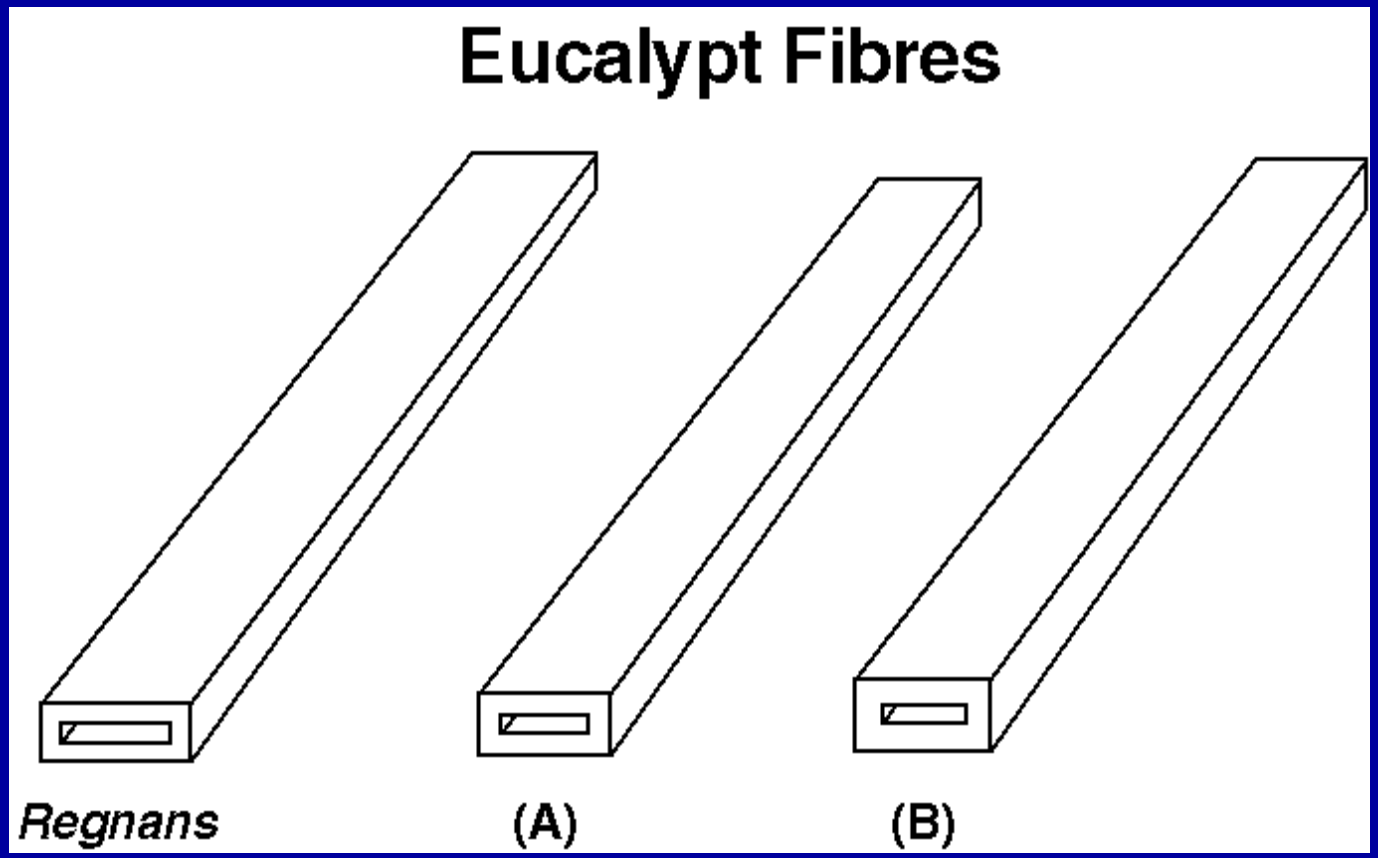
Eucalypt fibre types



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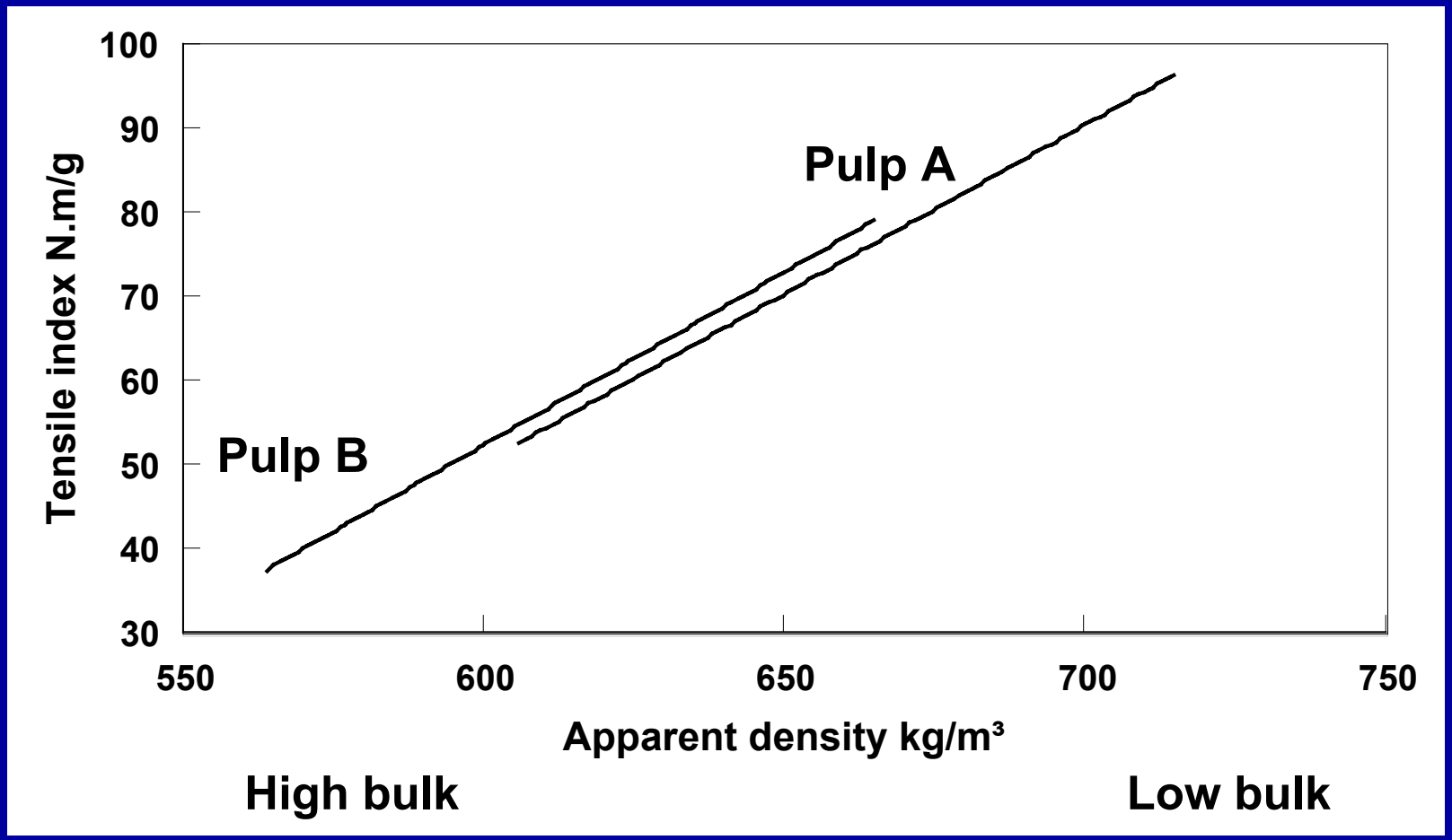
Eucalypt market kraft “A” & “B” categories



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Eucalypt market kraft pulps can

have very different papermaking properties

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Regnans grouping

- Thin walled (relative to perimeter), collapsed fibres compared to “A” and “B” groupings

- Handsheets: High bonding, high light scattering coefficient and opacity. Low bulk, low stiffness and low porosity

Eucalypt “A” grouping

- Fibre properties intermediate
- Handsheet properties intermediate

Eucalypt “B” grouping

- Thick walled (relative to perimeter), uncollapsed fibres compared to “A” grouping

- Handsheets: Lower bonding, lower light scattering coefficient and opacity, higher bulk, higher stiffness, and higher porosity

Fibres in eucalypt market kraft pulps

- Short
- Narrow / slender
- Generally of low coarseness
- Present in very large numbers in highly uniform populations

Compared with birch, aspen and mixed hardwood fibres

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References

- Kibblewhite, R.P.; Bawden, A.D. and Hughes, M.C.: Hardwood market kraft fibre and pulp qualities. Appita 44(5):325 – 332(1991).

- Kibblewhite, R.P., Johnson, B.I. and Shelbourne, C.J.A.: Kraft pulp qualities of *Eucalyptus nitens, E. globulus* and *E. maidenii*, at ages 8 and 11 years. New Zealand Journal of Forestry Science 30(3):-(2000).

2. Chemical and kraft fibre property variation within and among selected eucalypt trees and species

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For example

29 *Eucalyptus nitens* trees @ *age 15*

29 *E. fastigata trees @ age 15*

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Property variation with height above ground

Model predicted means

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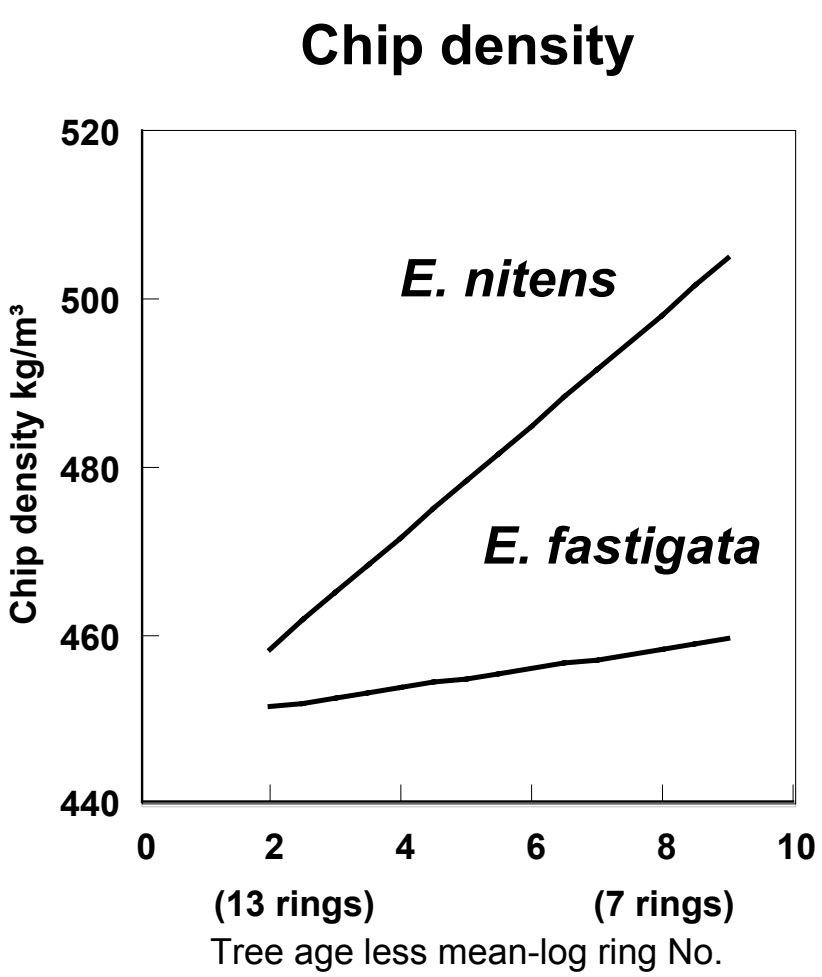
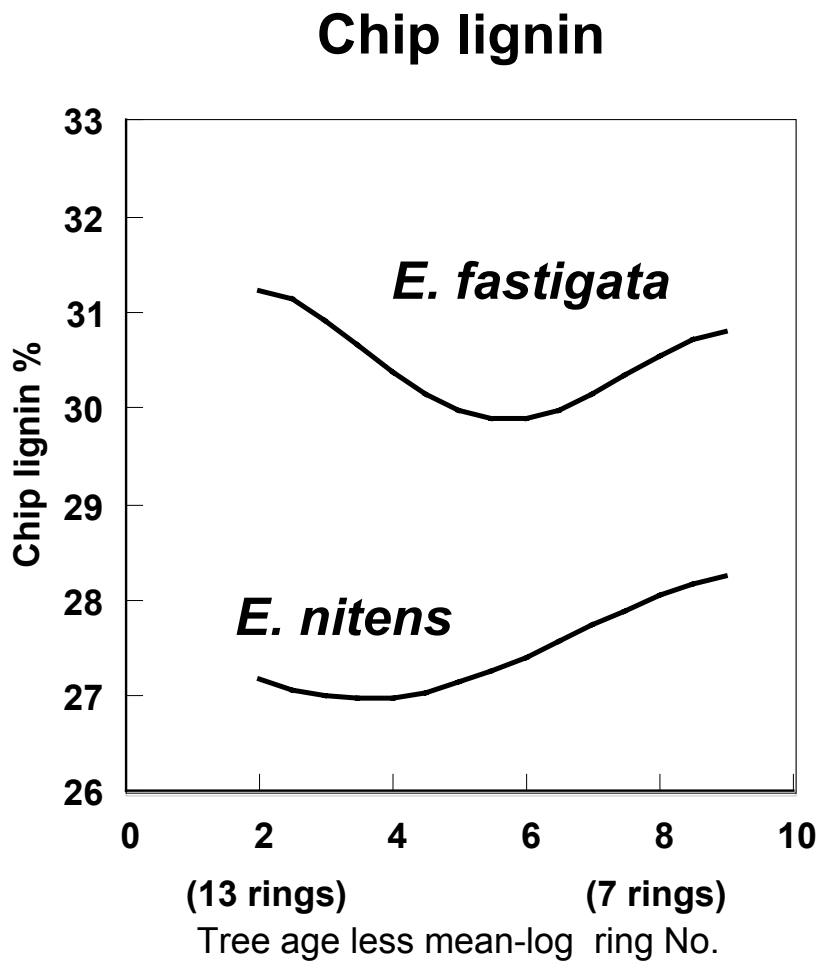
Chip density and lignin content





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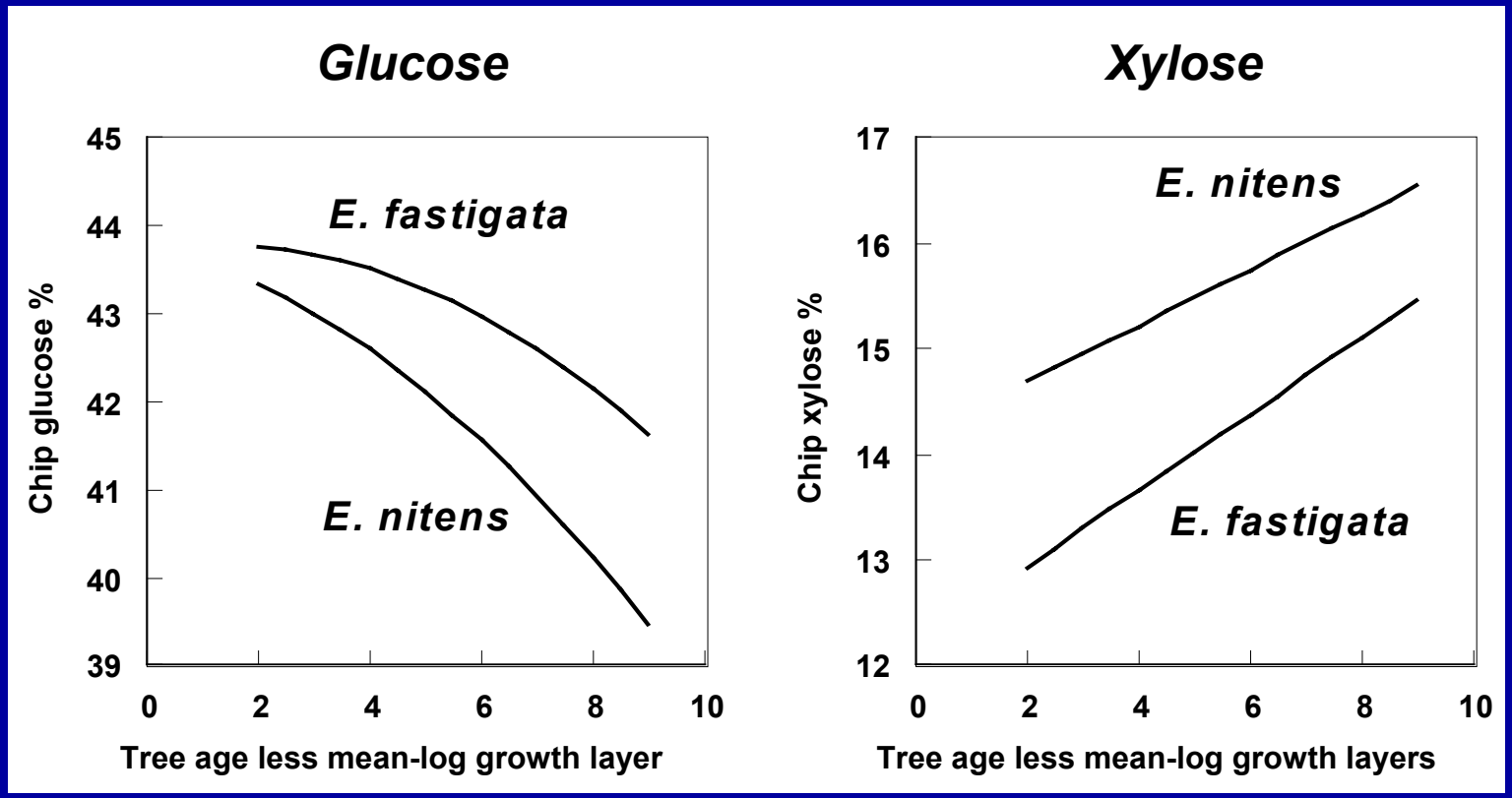
Chip glucose and xylose content



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Magnificent Variation within and among eucalypt trees and species

For example

Chip density and lignin content

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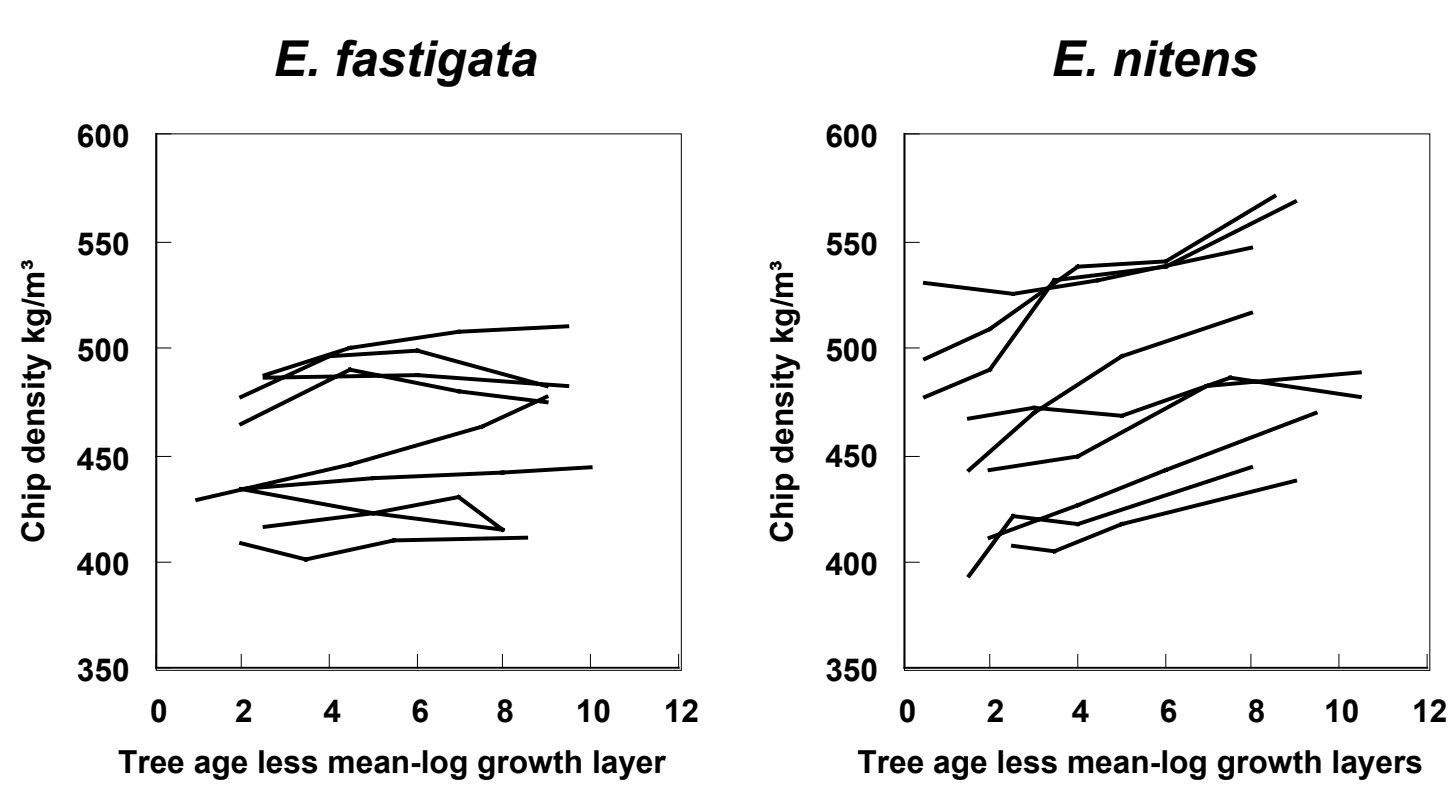
Chip density



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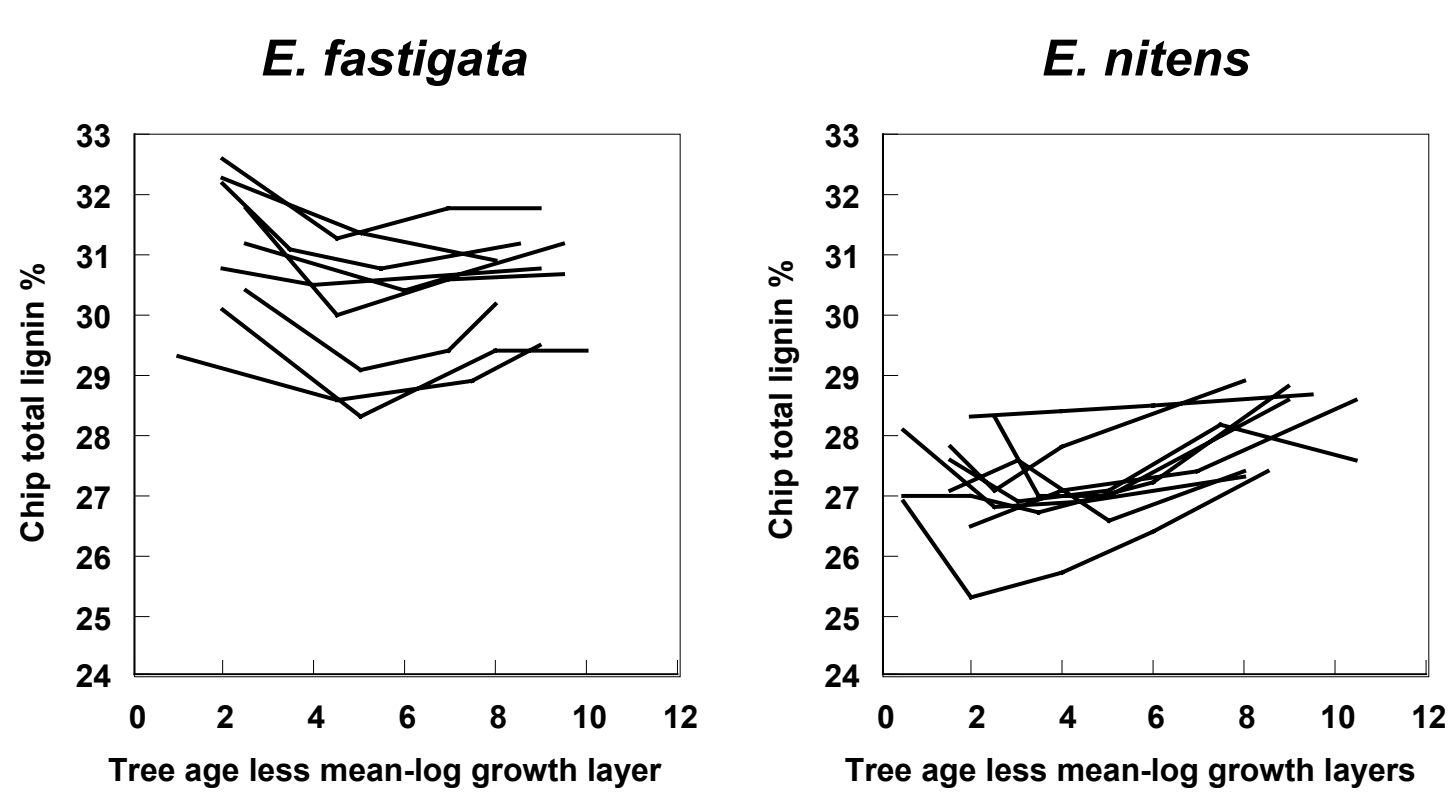
Chip total lignin %



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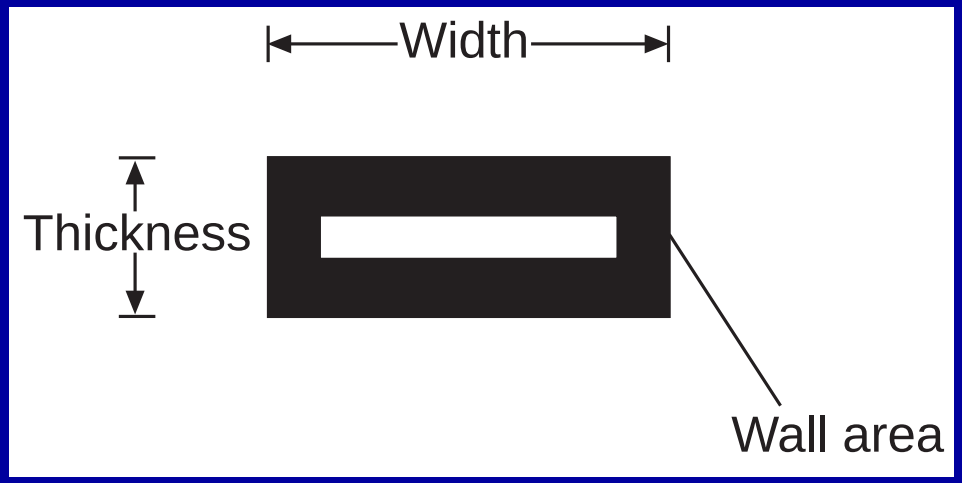
Kraft fibre property interrelationships
(Fibres dried and rewetted from handsheets)



Perimeter = 2(width + thickness)

Wall area ∝ Coarseness

Width/thickness = Collapse

Perimeter/wall thickness ∝ 1/Density ∝ Collapse

Number ∝ 1/(Length x Wall area)

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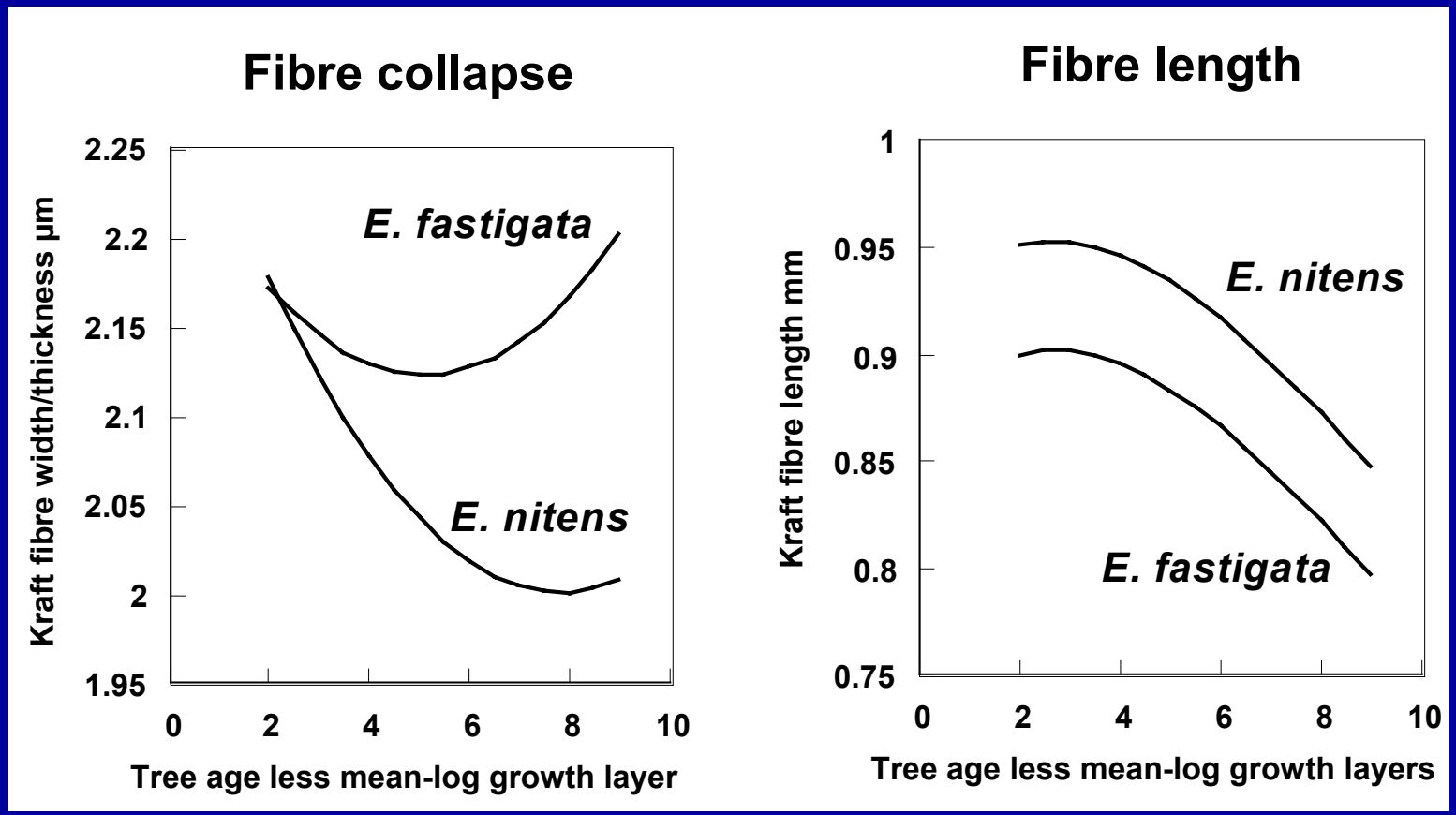
Fibre collapse and length



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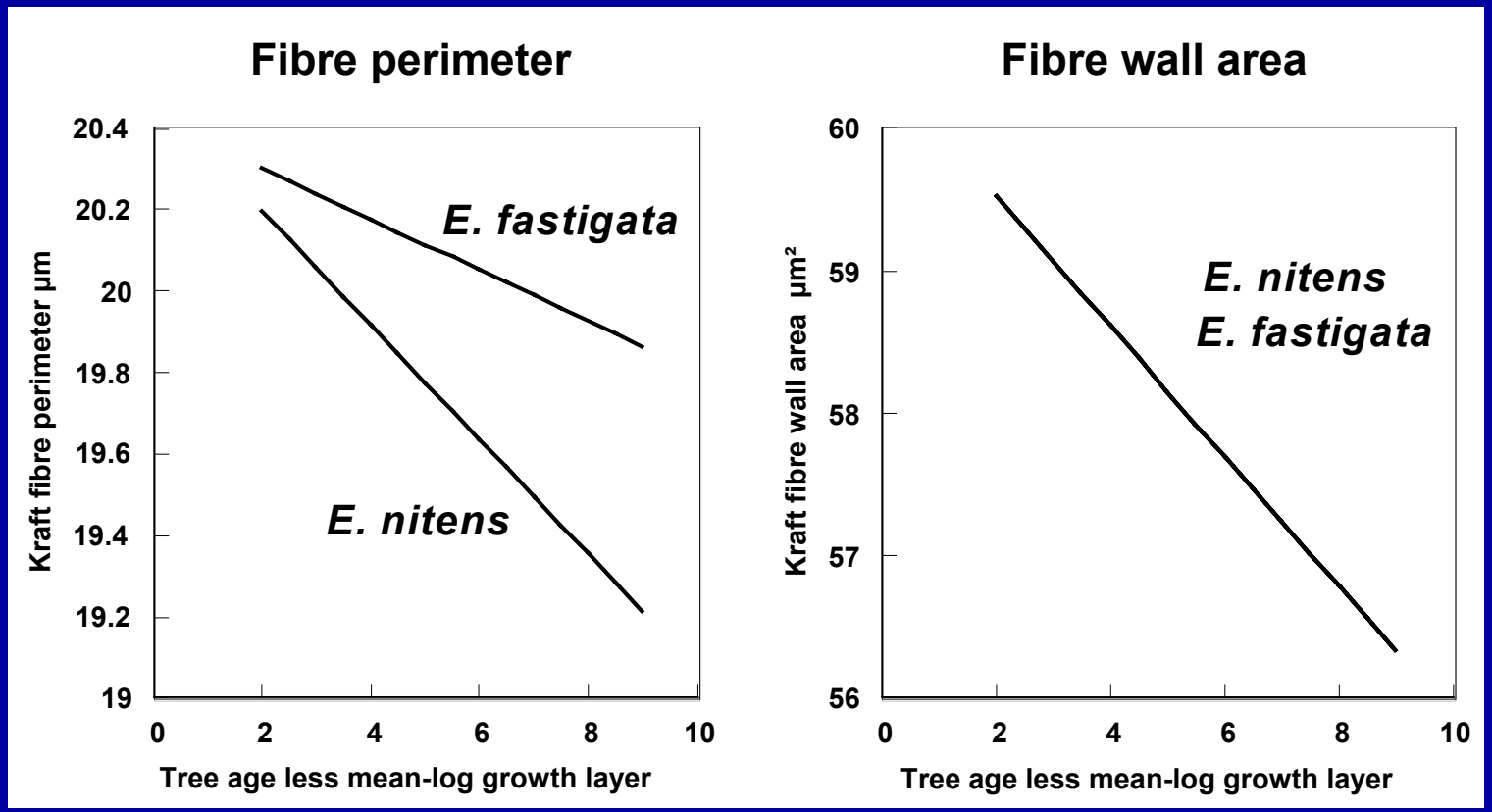
Fibre perimeter and wall area (coarseness)



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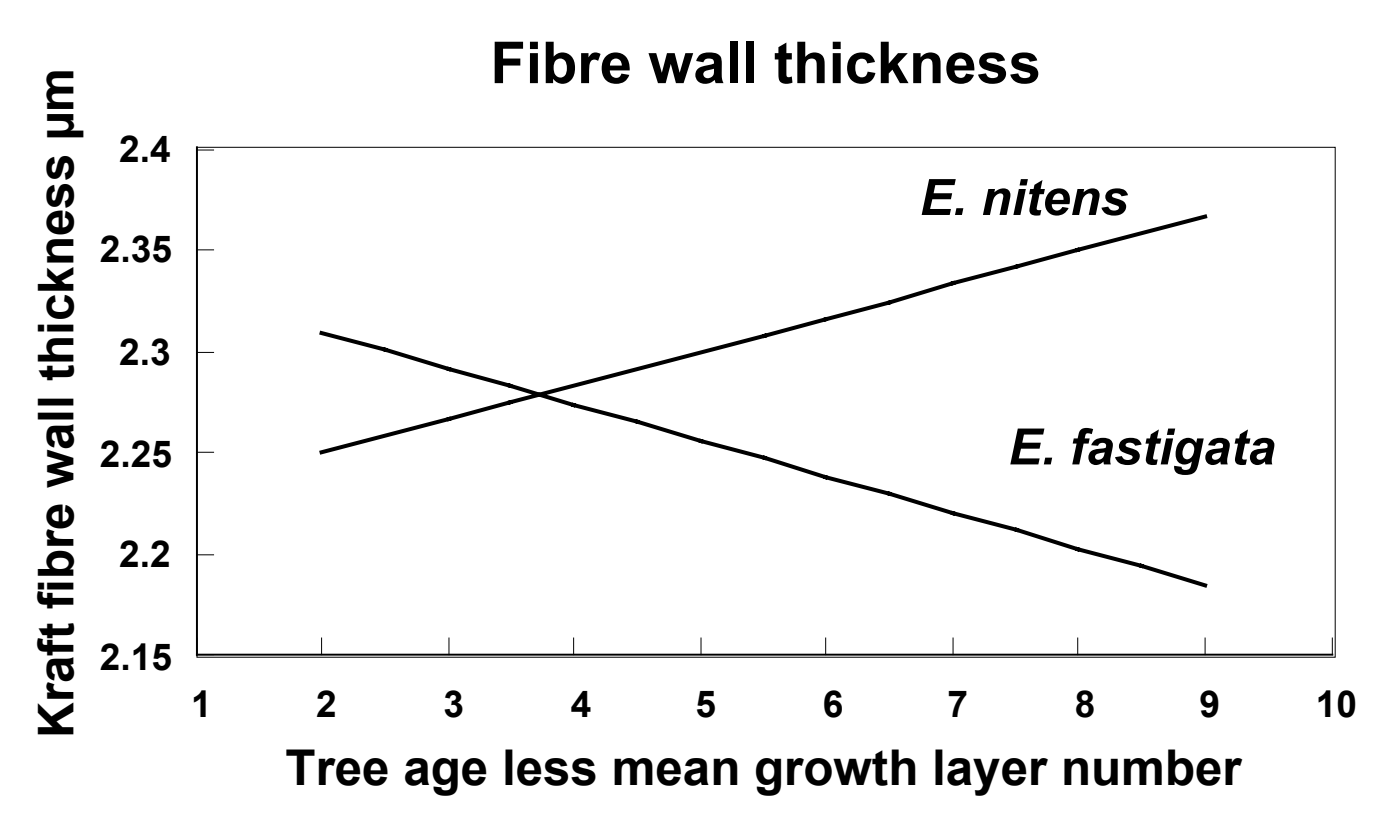
Fibre wall thickness



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E. nitens versus *E. fastigata*

For *E. nitens* with increasing tree height

- Fibre perimeter decreases rapidly
- Wall thickness increases

Thus for *E. nitens*

Chip density increases and fibre collapse decreases

(minimal change with tree height for *E. fastigata*)

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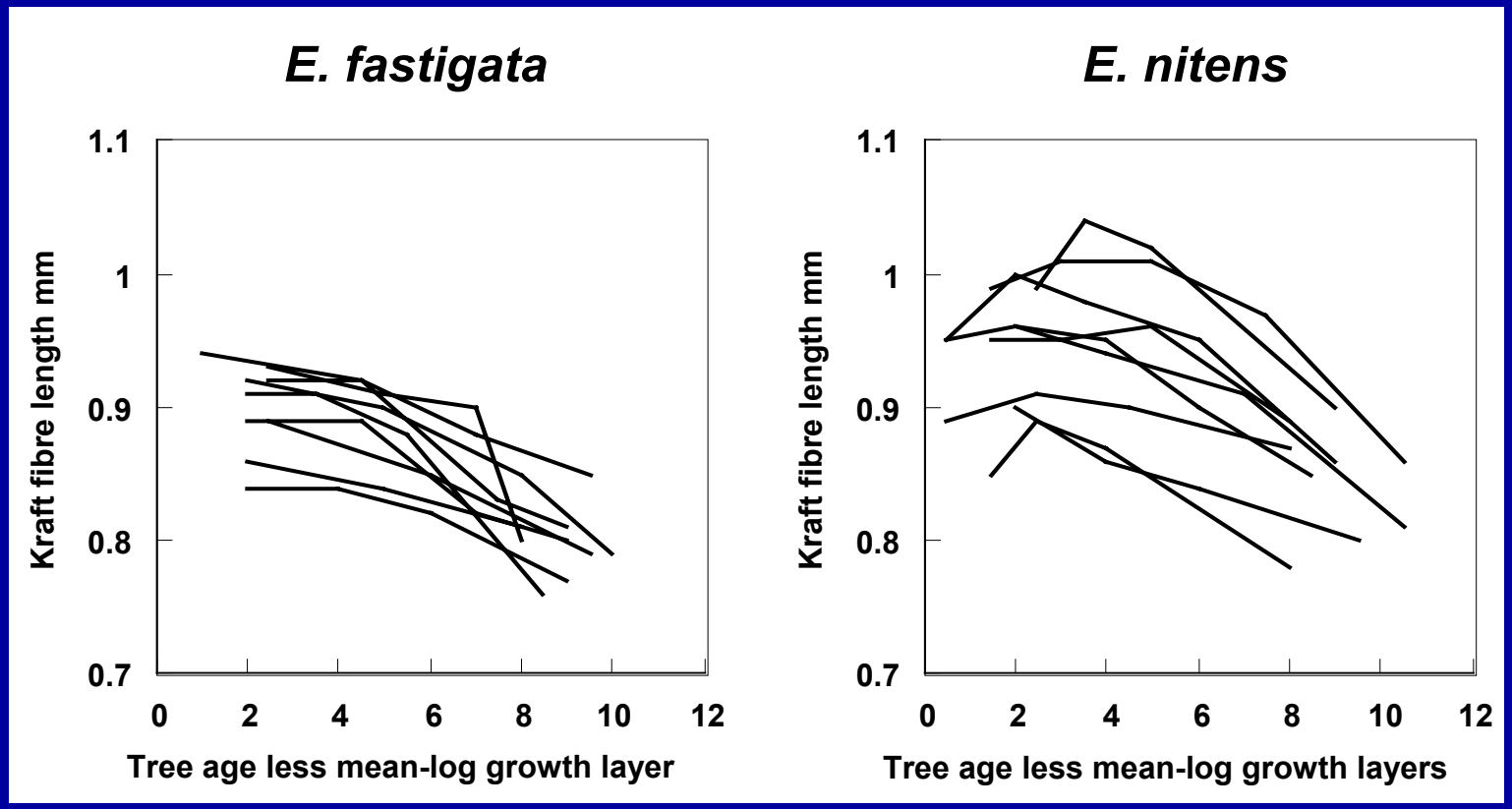
Kraft fibre property variation with length the example



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Chemical and kraft-fibre property patterns of change with tree-height

Very different for E. nitens and E. fastigata

- Wood lignin, glucose and xylose
- Kraft fibre length, perimeter, wall thickness and collapse
- Chip density

Similar for fibre wall area (coarseness)

References

- Kibblewhite, R.P. and Riddell, M.J.C.: Within-tree Variation of Some Wood and Kraft Fibre Properties of *Eucalyptus fastigata* and *E. nitens*. *Appita J.* 54(2):136-143(2001).
- Kibblewhite, R.P., Evans, R., Riddell, M.J.C. and Shelbourne, C.J.A.: Changes in density and wood-fibre properties with height position in 15/16-year-old Eucalyptus nitens and E. fastigata. *Appita J.* 57(3):240-247(2004).
- Kibblewhite, R.P., Evans, R. and Riddell, M.J.C.: Interrelationships between kraft handsheet, and wood fibre and chemical property interrelationships for the trees and logs of 29 *Eucalyptus fastigata* and *E. nitens*. *Appita J.* 57(4):317-325(2004).

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3. Selection of *Eucalyptus nitens* trees for different paper and pulp grades

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29 *Eucalyptus nitens* trees

15-year-old from same site
Selection - basic density @ 1.4 m
Kraft pulps @ kappa 20±2

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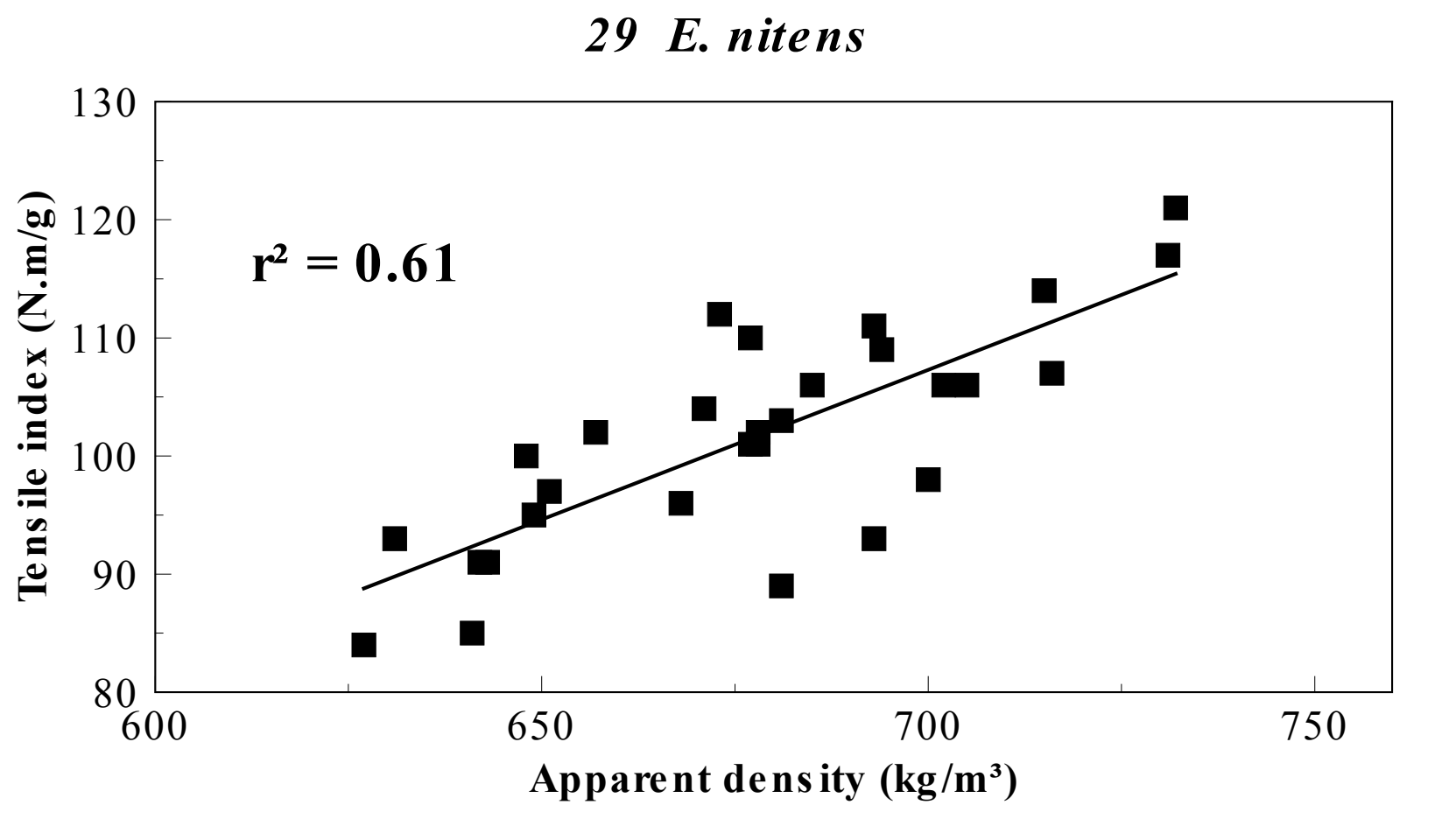
Tensile index versus sheet density
"29 *E. nitens* trees"



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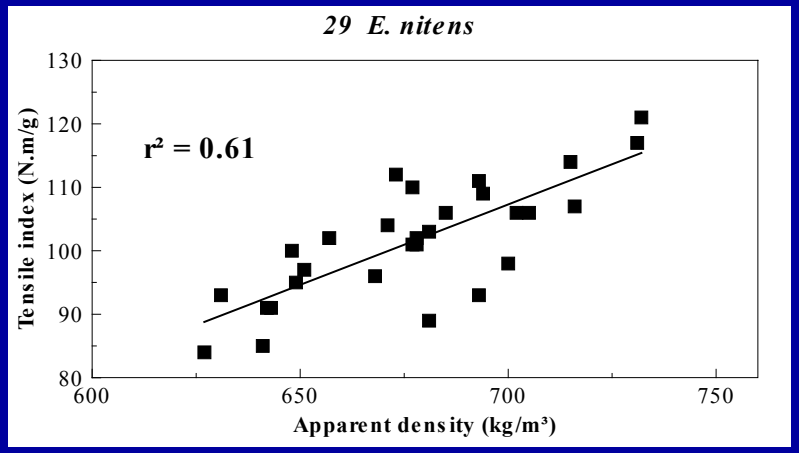
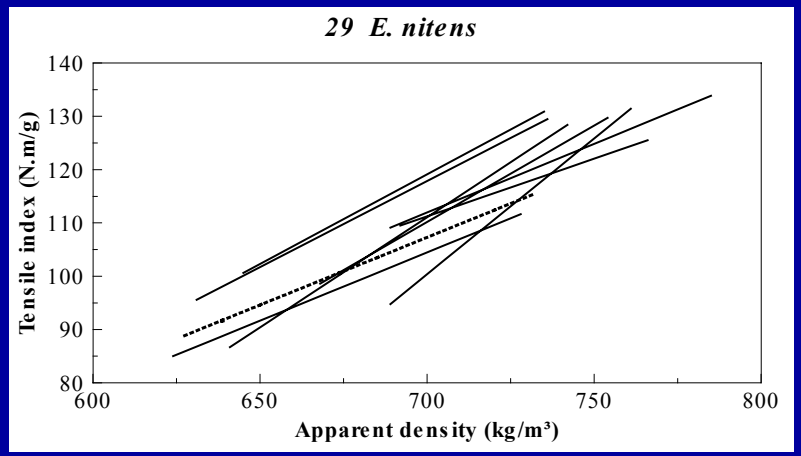
Unrefined versus refined "29 *E. nitens* trees"





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29 *E. nitens* trees

Individual-tree kraft pulps ordered

⇓

Increasing sheet density

⇓

Decreasing sheet bulk

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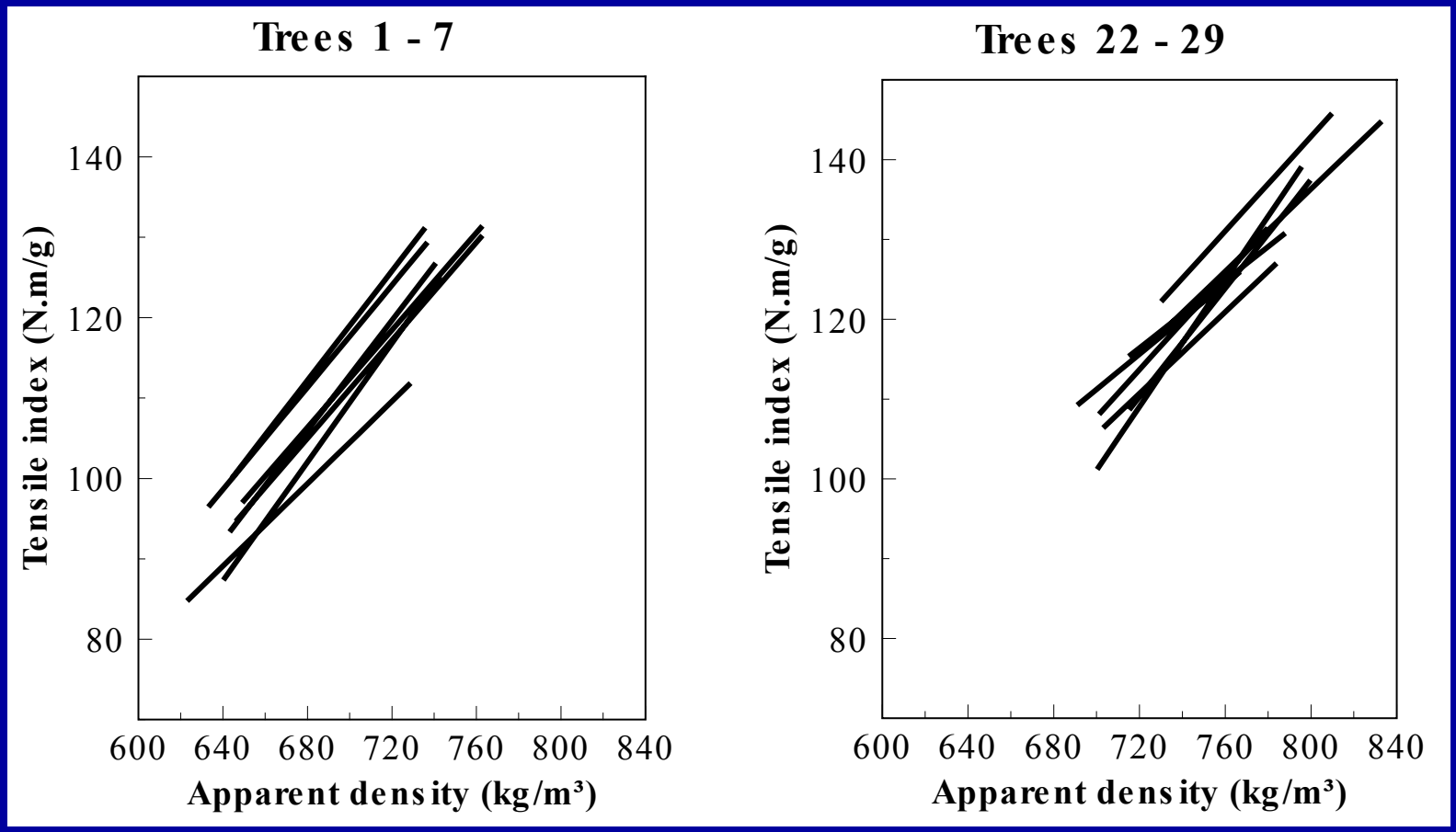
Provided sufficient bulk, tensile index can be developed with refining but not vice versa!



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Suggested end uses for some individual-tree fibre types

Eucalyptus nitens

Trees 1- 7 (high bulk)
Sheet density ≤ 650 kg/m³ @ 500 rev

Fibres relatively Short Slender Thick-walled	Tree 1 – 4 ⇒	<u>Excellent</u> • Bulk • Stiffness • Formation	<u>Wood-free</u> Printings and writings Tissue
Fibres relatively Long Slender Thick-walled	Tree 5 – 7 ⇒	<u>Excellent</u> • Bulk • Stiffness • <Formation	<u>Wood-free</u> Printings and writings Tissue

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Trees 11- 29 (low bulk)
Sheet density > 660 kg/m³ @ 500 rev

<u>Fibres relatively</u> Broad Thin-walled High collapse	Trees 11 – 16 ⇒	Low bulk	<u>Wood-free</u> Glassine papers Soft tissue – Low bulk component
<u>Fibres relatively</u> Broad Thin-walled > Collapse	Trees 24 – 29 ⇒	Extreme low bulk	Extreme high density papers

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Reference

Kibblewhite, R.P. and Shelbourne, C.J.A.: Genetic selection of trees with designer fibres for different paper and pulp grades. Transactions of the 11th Fundamental Research Symposium "Fundamentals of Papermaking Materials", Cambridge, September 1997.

4. Eucalypt-fibre selection for papermaking: *E. nitens*, *E. globulus* & *E. maidenii* at ages 8 and 11 years

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Two stand ages

- **8 years**
- **11 years**

Three species

- ***E. nitens***
- ***E. maidenii***
- ***E. globulus***

Chip density and pulp yield

	Chip density kg/m³		Pulp yield %	
	8 years	11 years	8 years	11 years
Nitens	447	448	53.0	55.6
Maidenii	569	576	55.0	55.5
Globulus	490	543	56.2	“54.5”

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Chip total lignin and pulp yield

	Pulp yield %		Total lignin %	
	8 years	11 years	8 years	11 years
Nitens	53.0	55.6	30.4	29.0
Maidenii	55.0	55.5	31.8	28.8
Globulus	56.2	“54.5”	31.9	27.4

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Chip carbohydrates and pulp yield

	Pulp yield %		% of total carbohydrates			
			Glucose		Xylose	
	8 yrs	11 yrs	8 yrs	11 yrs	8 yrs	11 yrs
Nitens	53.0	55.6	69.9	70.2	24.6	23.6
Maidenii	55.0	55.5	73.9	73.6	20.4	20.3
Globulus	56.2	“54.5”	72.3	74.6	21.9	20.4

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Handsheet bulk (or density)

”Critical eucalypt pulp quality determinant”

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Acceptable handsheet density range for eucalypt laboratory pulps

~600 - ~650 kg/m³
(@ 500 rev PFI mill)

Corresponding acceptable range for rewetted, bleached eucalypt market kraft

~560 - ~610 kg/m³
(@ 500 rev PFI mill)

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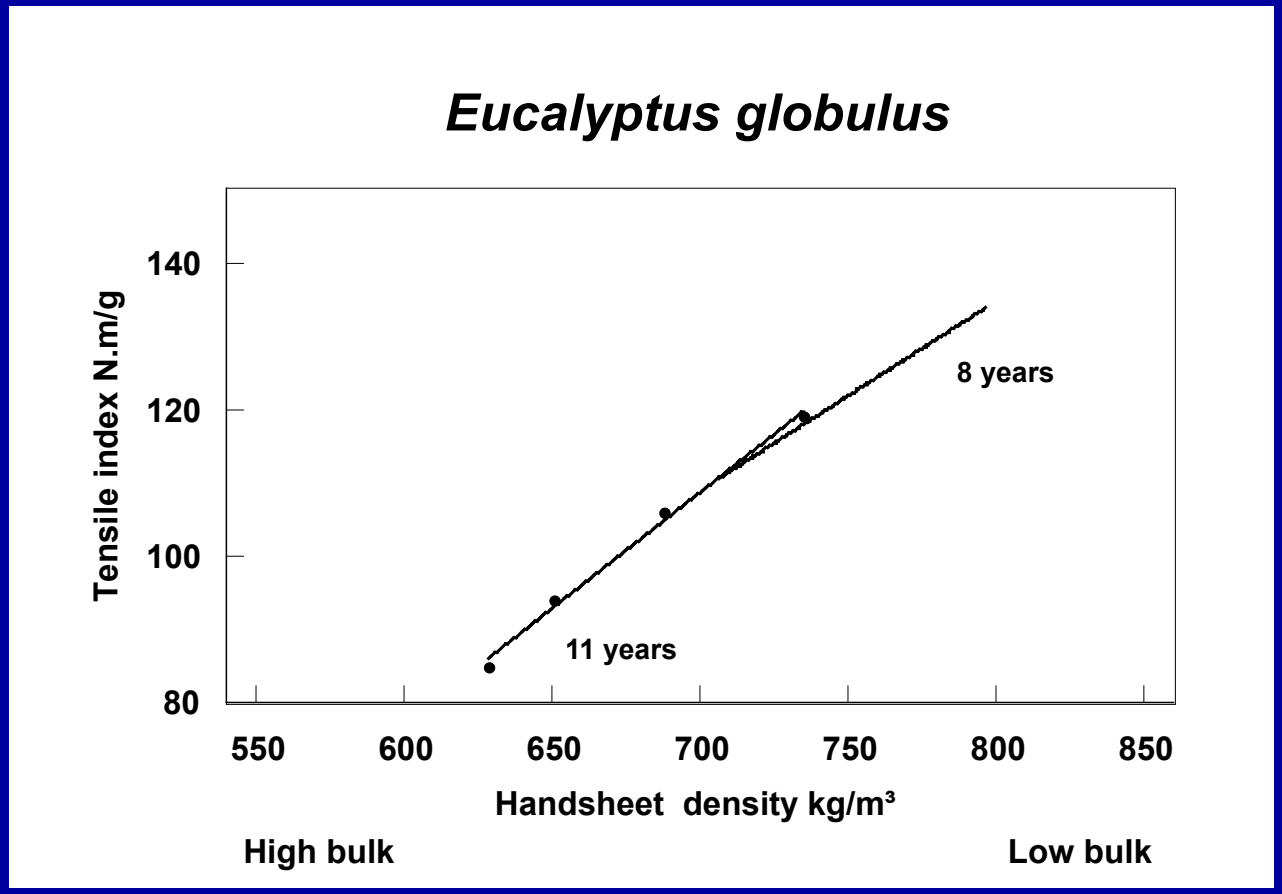
Tensile index versus sheet density
E. globulus aged 8 & 11 years



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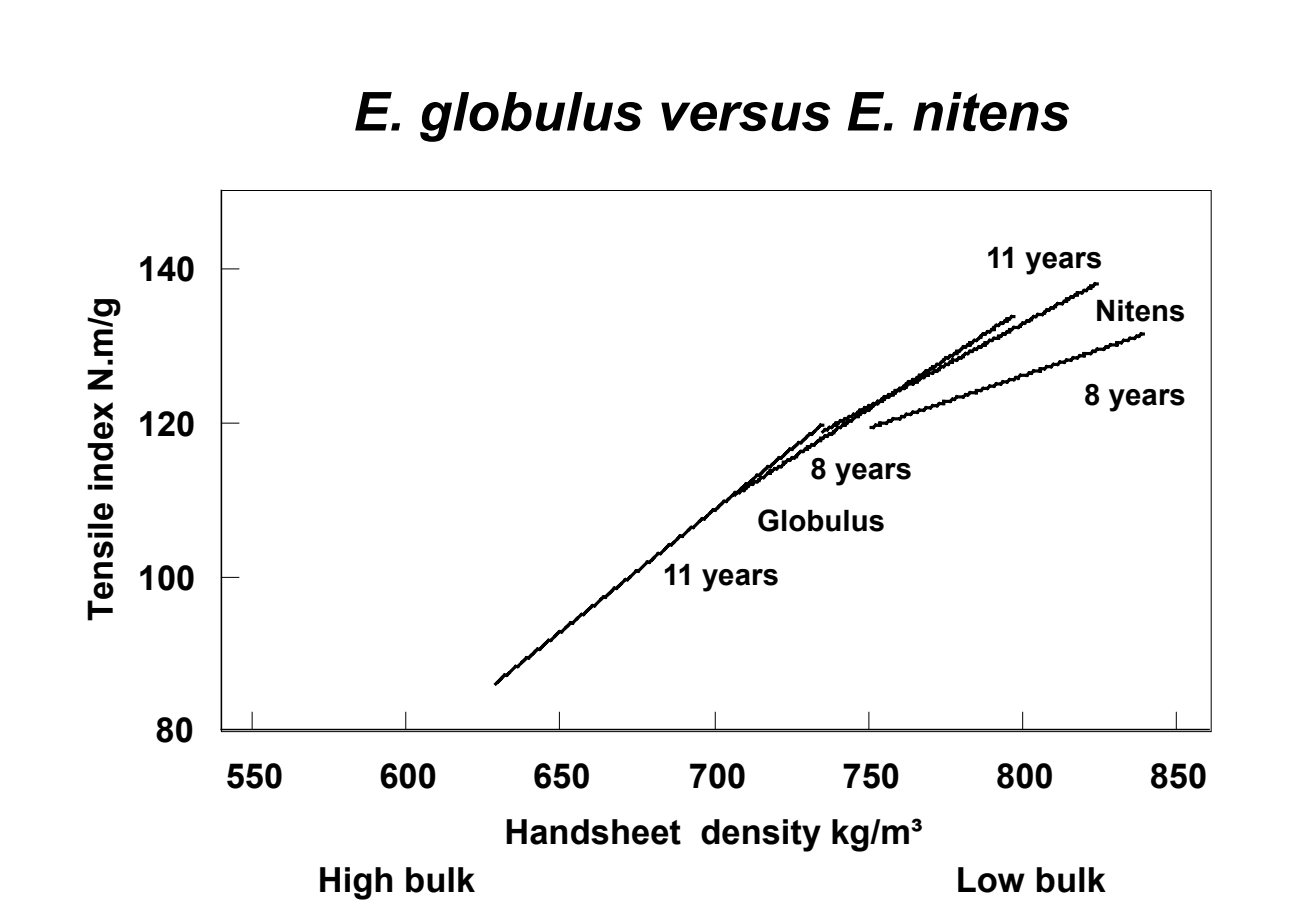
Tensile index versus sheet density
E. globulus & *E. nitens* aged 8 & 11 years



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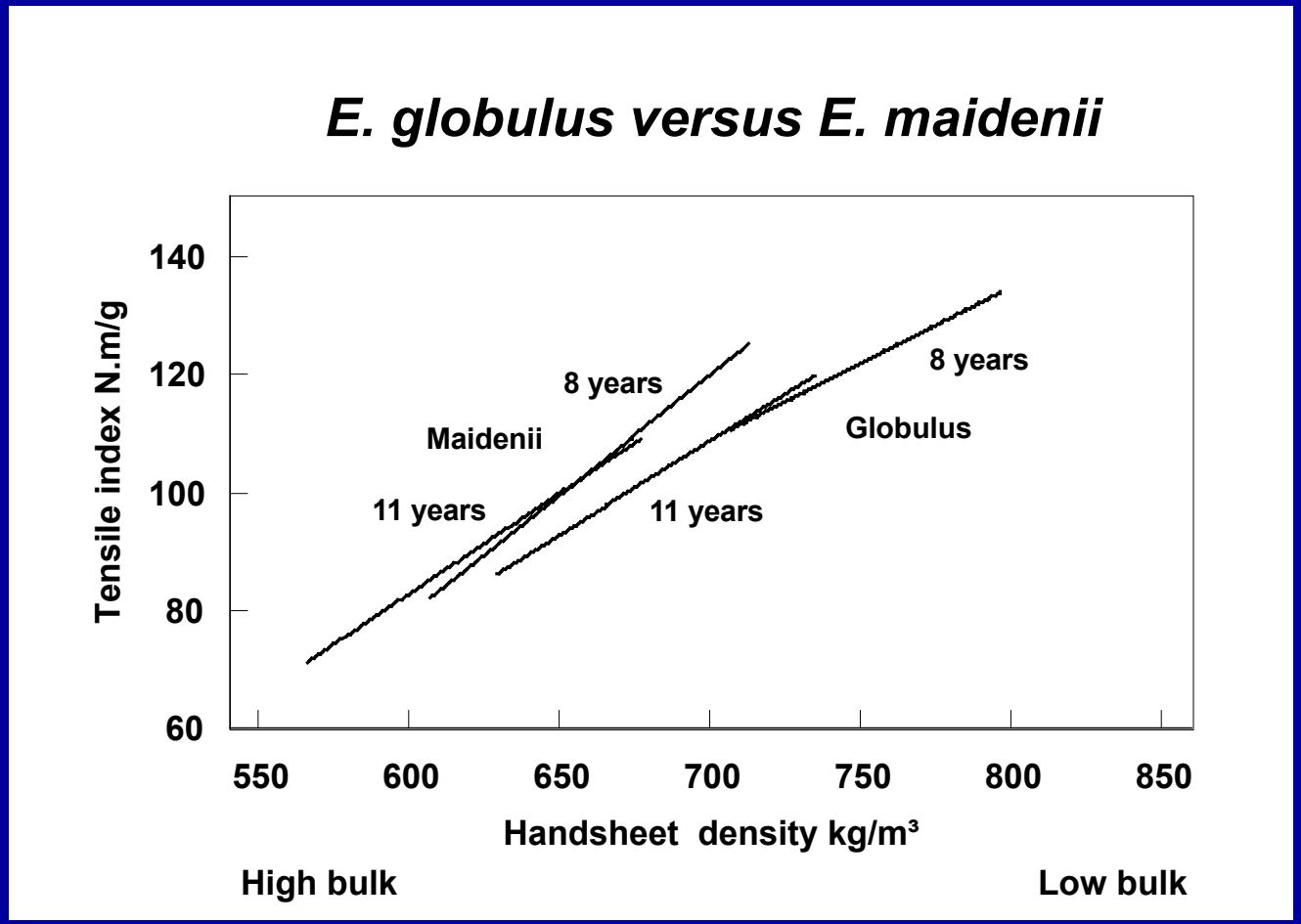
Tensile index versus sheet density
E. globulus & *E. maidenii* aged 8 & 11 years



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Eucalypt kraft pulps of premium quality

E. maidenii aged 6 - 8 years

E. globulus aged 11+ years

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Pulp quality
and
“Fibre dimensions”

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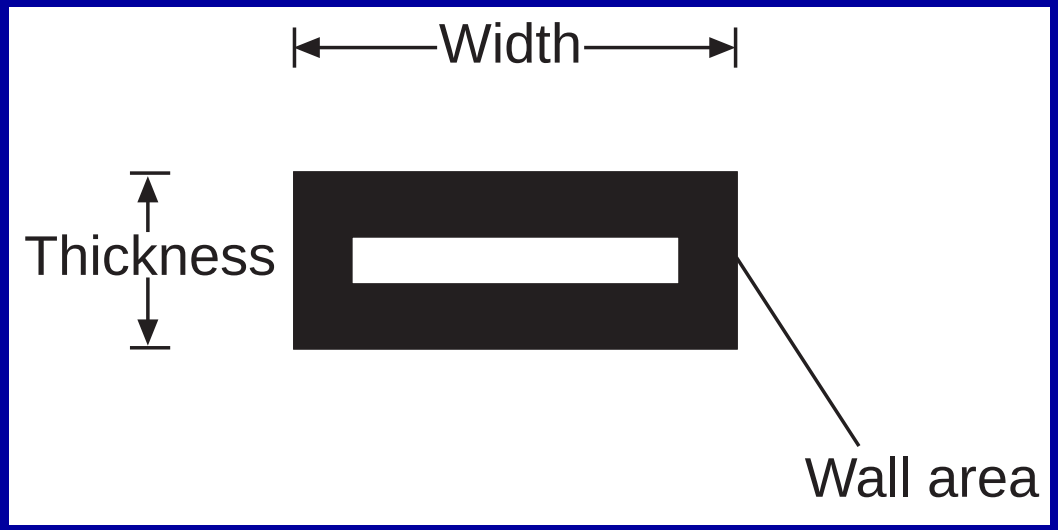
Fibre property interrelationships
(Fibres dried and rewetted from handsheets)



Perimeter = 2 (width + thickness)

Wall area ∝ Coarseness

Width/thickness = Collapse

Perimeter/wall thickness ∝ 1/Density ∝ Collapse

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Important fibre property relationships

	Nitens		Maidenii		Globulus	
	8 yrs	11 yrs	8 yrs	11 yrs	8 yrs	11 yrs
Perimeter	38.8	40.4	40.7	42.9	40.6	40.4
Wall thickness	2.10	2.16	2.59	2.80	2.16	2.48
Collapse	2.18	2.14	1.81	1.83	2.07	1.81

Kraft pulp quality determinants

	Nitens		Maidenii		Globulus	
	8 yrs	11 yrs	8 yrs	11 yrs	8 yrs	11 yrs
Length	**0.82**	**0.88**	**0.88**	**0.94**	**0.85**	**0.85**
Wall area	**50**	**56**	**64**	**73**	**57**	**62**
Collapse	**2.18**	**2.14**	**1.81**	**1.83**	**2.07**	**1.81**
Sheet density	**751**	**735**	**607**	**566**	**704**	**629**

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Premium eucalypt fibres
E. globulus (11+ years) & *E. maidenii* (~6-8 years)

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Summary

	Nitens		Maidenii		Globulus	
	8 yrs	11 yrs	8 yrs	11yrs	8 yrs	11 yrs
Chip density	X	X	Best	Best	Good	Good
Pulp yield	X	Good	Good	Good	Good	Good
Fibre length	Good	Good	Good	Good	Good	Good
Fibre quality	X	X	Good	X	x	Good
Pulp quality	X	X	Good	X	X	Good

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Eucalypt kraft quality requirements for laboratory-made pulps

Sheet density range

~600 - ~650 kg/m³
(@ 500 rev PFI mill)

- **Fibre length: ~0.8 - ~0.9 mm**
- **Fibre collapse: ~1.8 - ~1.9**
- **Appropriate fibre perimeter, wall thickness & wall area (coarseness) combination**

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Eucalypt kraft quality requirements for rewetted bleached market dry- lap

Sheet density range

~560 - ~610 kg/m³
(@ 500 rev PFI mill)

- Fibre length: ~0.65 - ~0.75 mm
- Fibre collapse: ~1.8 - ~1.9
- Appropriate fibre perimeter, wall thickness & wall area (coarseness) combination

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Reference

- Kibblewhite, R.P., Johnson, B.I. and Shelbourne, C.J.A.: Kraft pulp qualities of *Eucalyptus nitens, E. globulus* and *E. maidenii*, at ages 8 and 11 years. New Zealand Journal of Forestry Science 30(3): (2000).

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