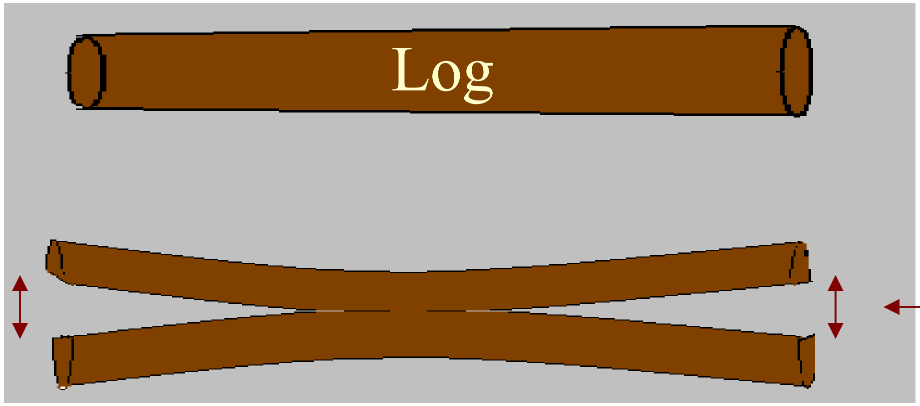
Pairing Test and Longitudinal Growth Strain: establishing an association



The paring test:
measuring the opening

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Background

Growth stress is a major concern in utilization of many hardwoods especially eucalypts as timber.

Larger growth stresses result in :

- Brittleheart in standing trees {Low value corewood}
- End-splits in logs {Low recovery of sawn timber}
- Warp and twist in sawn boards {Excessive planning and low productivity}

A typical growth stress distribution

Longitudinal growth stress varies progressively from tension at the cambium to compression at the pith.

The transition occurs about one-third of the way from the cambium to the pith.

The gradient in longitudinal growth stress within the log determines the severity of distortion in sawn timber.

The outward warp of the two half-rounds from a log sawn along the pith - the “pairing test” - is associated with growth stress gradient.

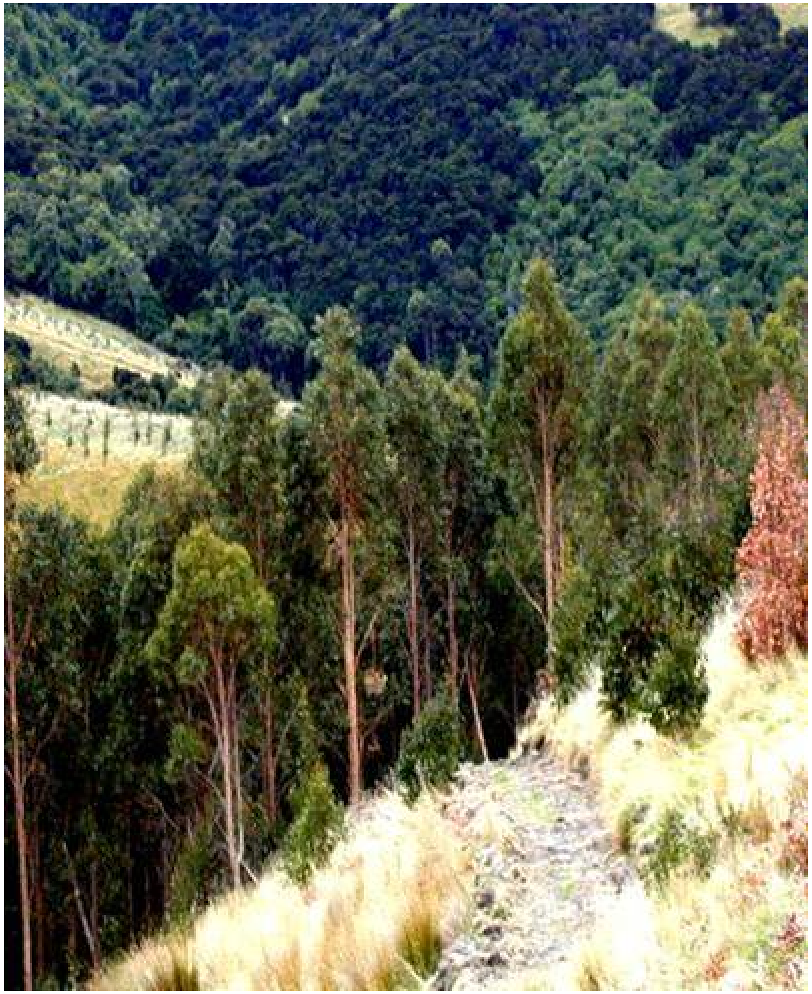
The quest……

To establish a correlation between the measured surface growth strain and the magnitude of outward warp or log-opening of the two half-rounds.

To describe a mathematical expression that links longitudinal growth strain to outward warp.

Study material

- Sixty-three trees from a 10 yr-old stand of *Eucalyptus nitens*
- Genetic source – unknown
- Location – Port Hills (near University of Canterbury)
- Grown on a north-easterly sloping site
- Exposed to strong winds



Sampling
(63 trees)

Measurements

- Acoustic Velocity
- Growth Strains
- Log Opening on Sawing

Measurement of acoustic velocity

Each log was tapped at one end with a hammer to launch a stress wave.

Reverberation of the sound wave along the log was captured by an accelerometer placed at the same or opposite log end.

The resonance frequencies of the log were identified.

A typical WoodSpec output

Acoustic velocity (*c*) is calculated from the fundamental frequency (*f*) and the log length (*l*)

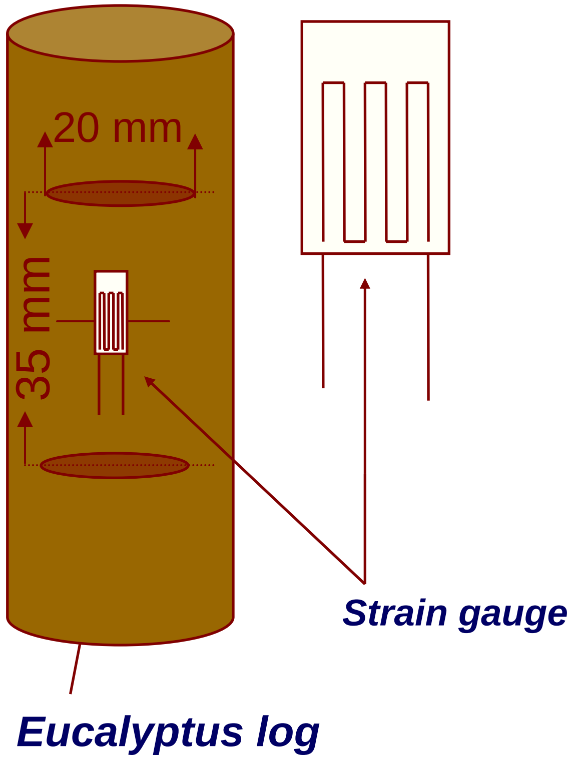
$$c = 2 \times l \times f$$

The mean stiffness of each log is calculated from the general equation

$$E = \rho \times c^2_{resonance}$$

where ρ *is the green density*

Measurement of longitudinal growth strain



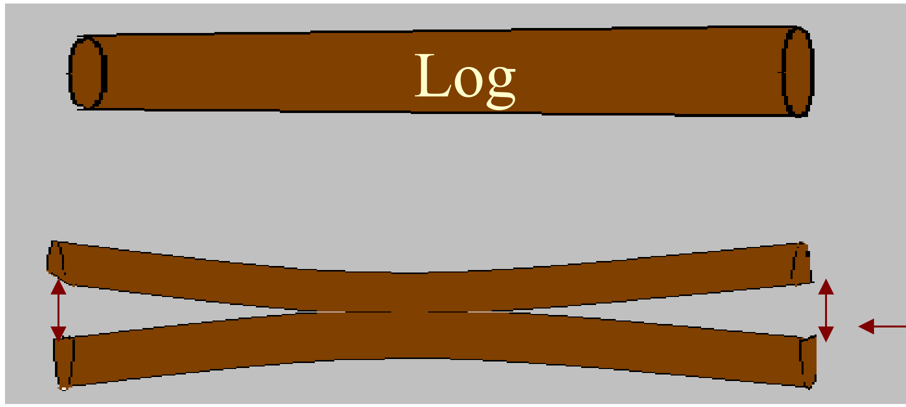
- Stress cannot be measured directly; need strain measurement
- Longitudinal growth strain measured by a strain gauge
- Growth strain was measured at mid-length and on two opposite sides of the stem/log

• Strain gauge was glued to the cambial wood surface.

• Wood fibres were cut above and below the gauge to release the growth stress.

• The released strains were recorded.

Distortion in half-rounds after sawing the logs



Measure the opening

Sawing

Simple statistics

Variables	Butt log			Second log		
	Mean (Sd)	Min.	Max.	Mean (Sd)	Min.	Max.
Growth strain (10^{-6})	933 (454)	340	2600	855 (346)	371	1610
Acoustic vel. (km/s)	2.87 (0.23)	2.32	3.44	3.07 (0.25)	2.42	3.85
Log opening (mm)	19.05 (6.38)	8.8	38.3	47.29 (18.19)	21.3	92.8

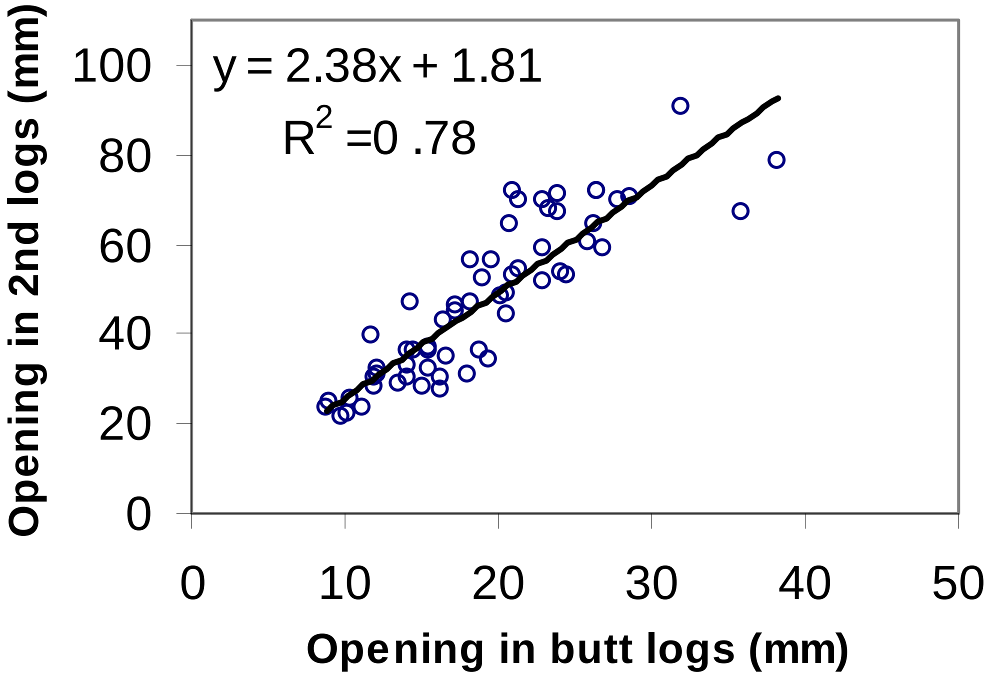
Differences in log opening

There is a large variation in log openings

Butt logs ends opened less compared to the second logs

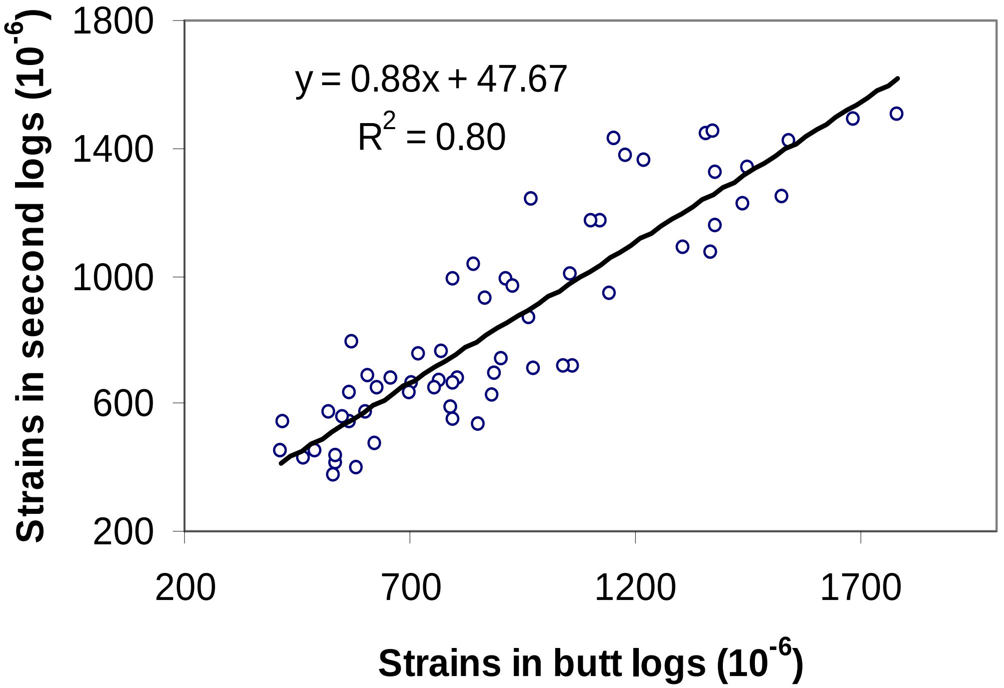
Second log opening was ca. 2.5 times that of butt logs

Opening in logs



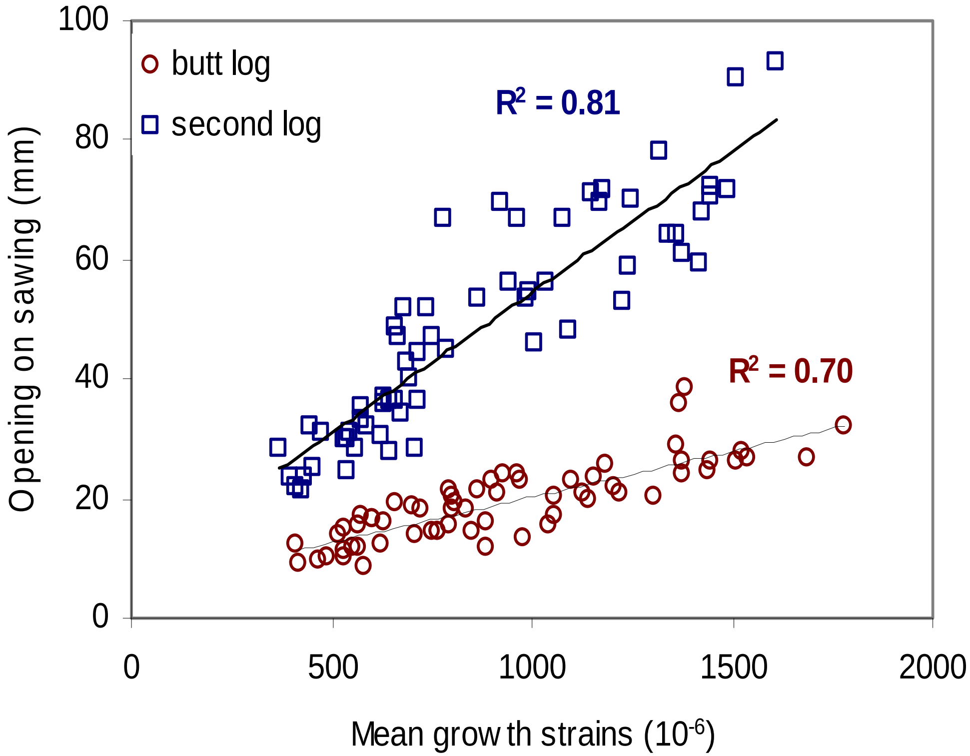
There is a strong association between extent of opening in the butt log and in the second log

Growth strains



Growth strains of butt and second logs were equally highly correlated

Association of growth strain with log opening

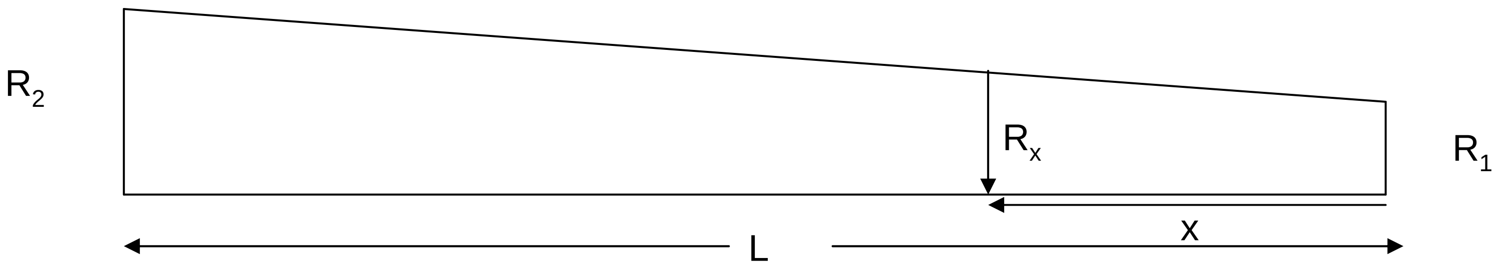


Opening in individual logs is influenced by the surface growth strains as well as log dimensions

Explaining the log opening

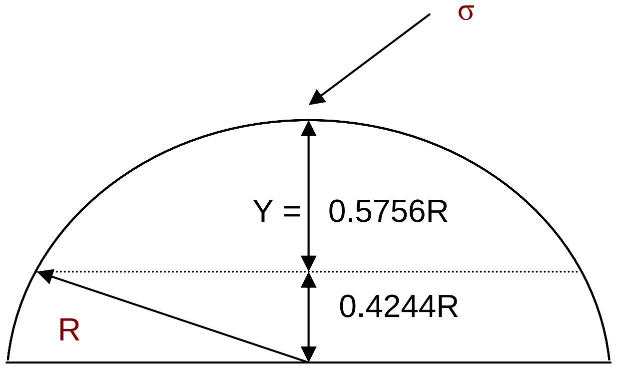
A theoretical model based
on
the bending of a tapered beam

Model for opening



Considered a beam of length “L” and semicircular cross section tapering from R_2 to R_1

For a semicircular cross section the neutral axis is at **0.5756R** from the surface and moment of inertia is **$0.1098R^4$**.



The developed model equation is

$$Y_0 = \frac{1.74\sigma_s l^2 R_a^3}{E \times R_2^2 (R_1 - R_2)^2} \left[\frac{1}{6} + \frac{R_2^3}{3R_1^3} - \frac{R_2^2}{2R_1^2} \right]$$

where "Y_0" - log opening; "E" - average MoE of log and "σ_s" - surface growth stress

Surface growth stress can be estimated from outerwood MoE "*K*" and surface growth strains "ε_l"

$$\sigma_s = K\varepsilon_l$$

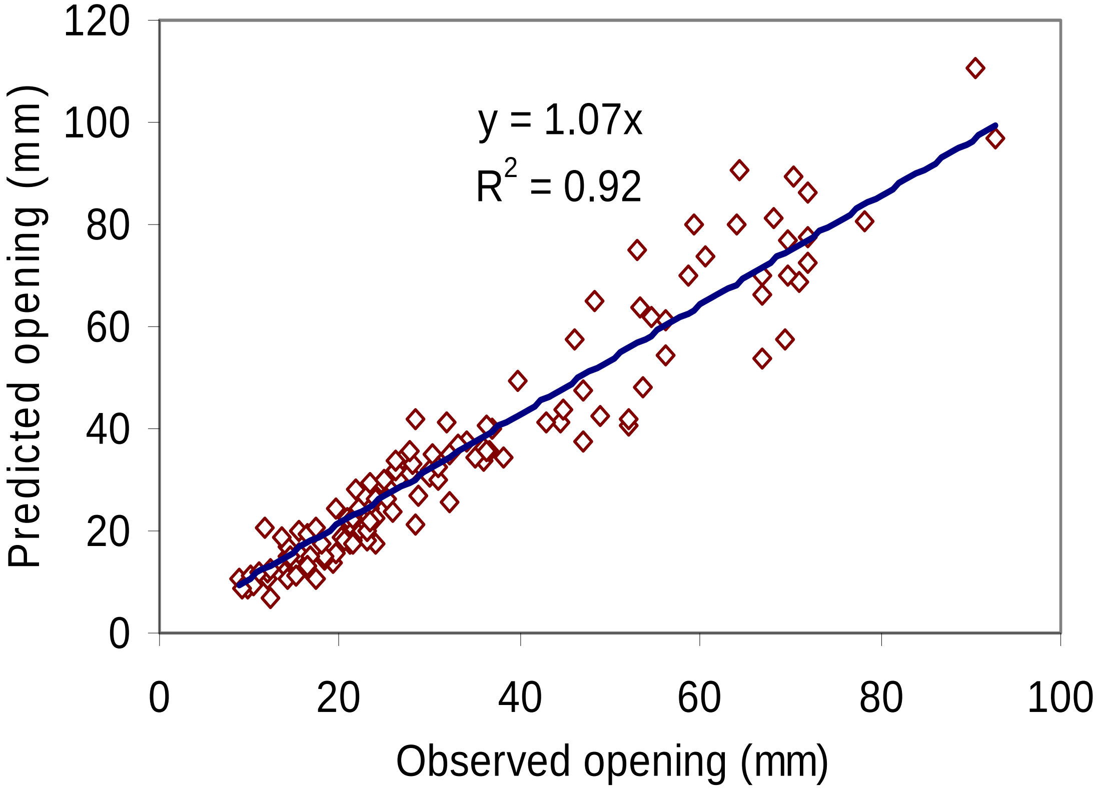
The model equation can be rewritten as

$$Y_0 = \frac{1.74 K \varepsilon_l l^2 R_a^3}{E R_2^2 (R_1 - R_2)^2} \left[\frac{1}{6} + \frac{R_2^3}{3R_1^3} - \frac{R_2^2}{2R_1^2} \right]$$

in which "K" and "E" are estimated from

$K = \rho * C^2_{transit\text{-}time}$ *and* $E = \rho * C^2_{resonance}$

Model validation



Model predicted opening agrees well with the observed opening

Outcomes

- Confirmed the association of “pairing test” with growth stress in log.
- Opening in logs is a function of longitudinal growth strain, log dimensions and the ratio of outerwood to average stiffness of log.
- The model equation can effectively be used to predict the magnitude of distortion in logs on sawing knowing the growth strain and *vice versa*.

Implications

- A prior knowledge of growth strain and associated warp can help determine the appropriate processing strategies for logs.

- The method can be used in tree breeding.

  The “pairing test” could be used an alternative method for rapid screening of low strain eucalyptus clones at an early age.

THANK YOU