Director

Breeding for Wood Quality; Acoustic Tools and Technology

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Contents

- Why acoustics?
- How acoustics work
- Results, tricks and traps
- Who's doing it?
- Conclusions

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Why? Global developments

- Resource wood quality is changing, target of value improvement
  - Global emphasis on structural and appearance qualities
  - Age of clearfall declining, log quality more variable
  - Tree breeding has improved volume more than quality
- Increased attention to quality standards eg NZ Standard 3622
  - Development of 'verified visual' grading (sample proof tested)
  - Price differential in lumber and engineered wood markets
  - Mills sensitive to stiffness of smaller diameter young wood
- New tools – Structural and LVL mills can now measure stiffness

Breeding for stiffness will enhance business returns

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Why? Financial values

What is stiffness worth – a couple of examples

- Verified visual grading – batch pass/fail
  - VSG8 lumber premium is NZ\$100/m^3 (\$450 vs \$350)
  - At 55% conversion, 80% structural, equates to \$36/m^3 log
  - At 600m^3/ha, 70% sawlog, 27 yrs, 8%, equates to \$1,893/ha
- MSG lumber – incremental benefit
  - MGP8 lumber premium is NZ\$250/m^3
  - 0.1km/sec gives 5% more MGP8, worth \$12.50/m^3
  - At 600m^3/ha, 70% sawlog, 27 yrs, 8%, equates to \$657/ha

Breeding for stiffness will enhance business returns

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Why? Financial values

What is stiffness worth – more examples

- Sitka Spruce – United Kingdom
  - Structural £150, Industrial £100
- Spruce – Sweden
  - MSR 1,450kr, Visual structural 1,350kr
- Douglas fir – Oregon, USA
  - MSR $350, Visual structural $310
  - LVL $350, Ply $230
- Southern Yellow Pine – Arkansas
  - MSR $195, Visual structural $178

Absolute differences vary with market conditions – premiums remain

Breeding for stiffness will enhance business returns

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Why? Financial values

Other values are significant too

- Microfibril angle
  - R^2 in range 0.8 – 0.9
  - MFA is key predictor of solid wood stability and fibre stiffness
- Pulp & Paper properties
  - Fibre length and paper strength
  - Coarseness and sheet quality
  - Energy consumption and yield
- Eucalypt stiffness
- Ash group Eucalypt internal collapse

Breeding for stiffness will enhance business returns

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Why? Feasibility

Hitman ST300

- New tools are quick, non-destructive, easy and efficient
  - Less than 1 minute/tree for testing
  - Wireless, with no cables to tangle or fail
  - Quick and easy insertion and removal of probes
  - No cores needed
  - No significant damage to young trees
- Mechanical and software enhancements improve precision
- Variability and heritability are high
- Breeding program on 10,000ha/annum could deliver >$10m/annum

Sonic speed provides an attractive breeding opportunity

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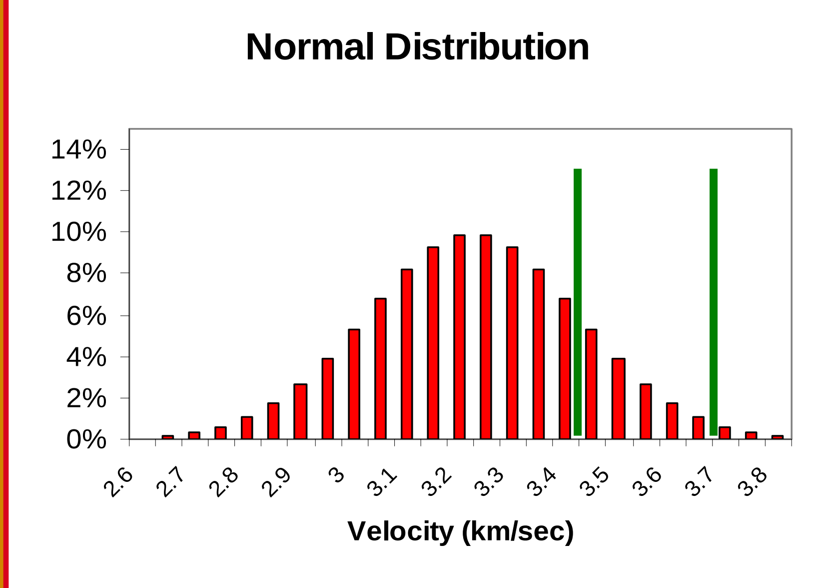
Why? Feasible and valuable

Hitman ST300

- Variability and heritability are high
- Example mean 3.2 km/sec with SD 0.2
- Top 10% mean is 3.5 km/sec
- Top 2% mean is 3.63km/sec
- With heritability of 60%, delivered gain is 0.18 and 0.26 respectively
- MSG example values this at $1,180 and $1,700/ha NPV at time of planting



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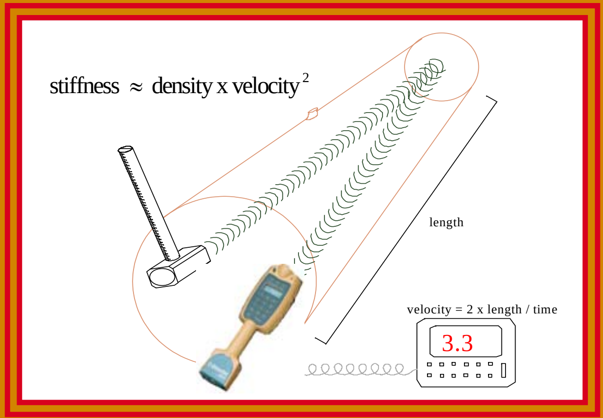
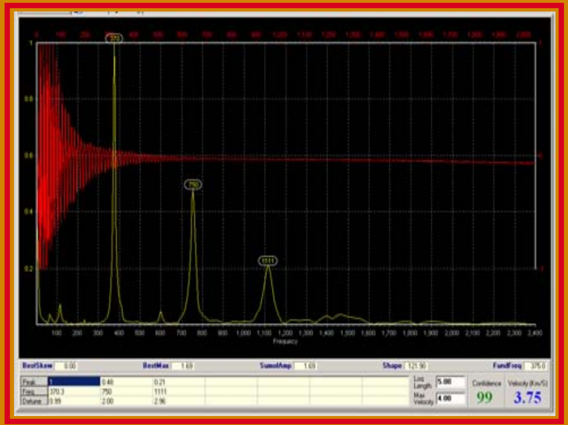
HM200, LM600 – how they work

- Stiffness = density x $(\text{velocity})^2$
- Velocity is derived from resonant frequency (2nd harmonic) and length
- Sensor/microphone detects frequency from hammer blow
- Green density is relatively constant





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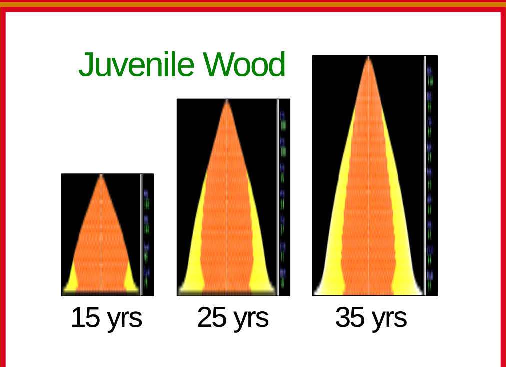
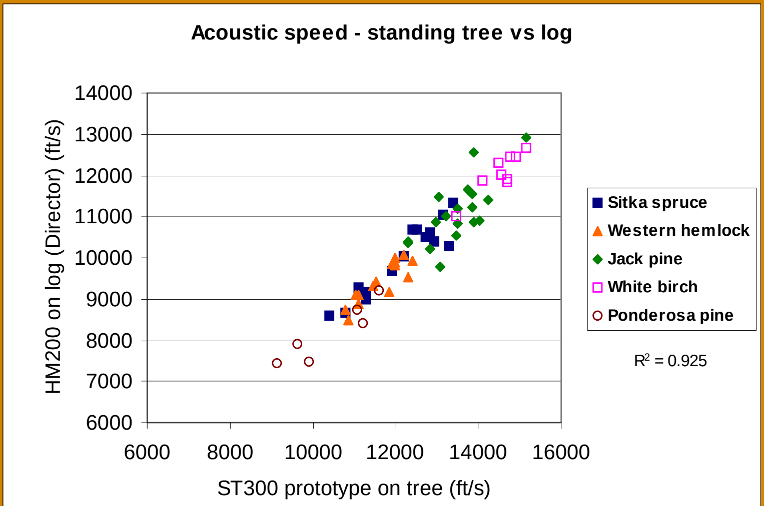
Hitman ST300, PH330 – how they work

- ‘Time of flight’ outerwood velocity measure – higher than log measure
- Ruggedised, waterproof, wireless, auto-distance, audible and visual output, interface to PDA
- Velocity correlates strongly with log velocity at stand level





Source: X Wang et al, University of Minnesota

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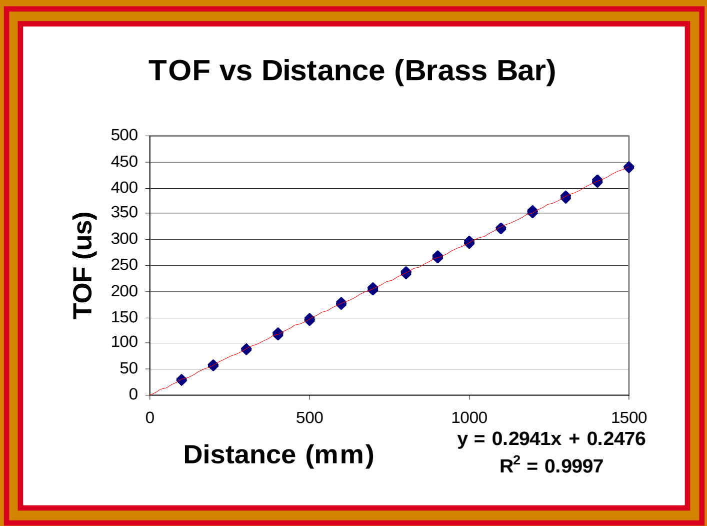
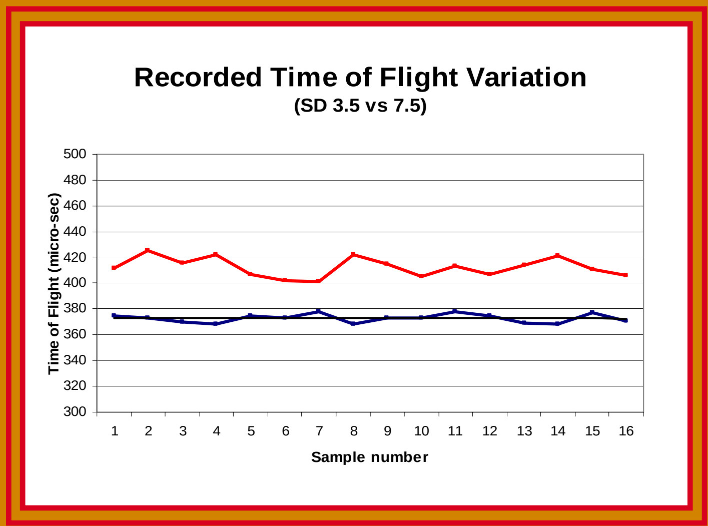
Improved Precision

Hitman ST300

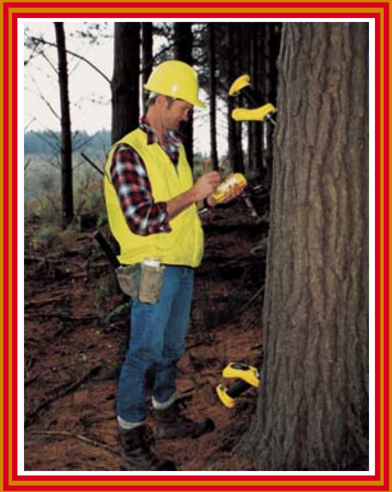
- Mechanical and software enhancements improve precision
  - Calibration against absolute standard
  - Filters enhance precision





Standing tree sampling – single trees

- Measure is a single sample of outerwood velocity
- Sampling procedure and intensity must match need
- Single tree - intensive sampling
  - Variation around stem
  - Knot location
  - Transverse
  - Compression wood
  - Hit variability



- 1-3 sets of 10 hits, in each of 2-4 locations around stem
- High productivity (>60 sample sets/hour) – faster than density coring

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Standing tree sampling – single trees

- Eyrewell study – radiata pine, age 28
- Correlation between standing tree and log velocity improves as sample intensity increases

Location/s on tree	taps	R^2
Upper side	3	0.44
Upper side	3	0.48
Upper side	3	0.43
Upper side (A)	9	0.50
Lower side (B)	9	0.45
Random side (D)	9	0.60
Mean A+B	18	0.61
Mean A+D	18	0.62
Mean A+B+D	27	0.67

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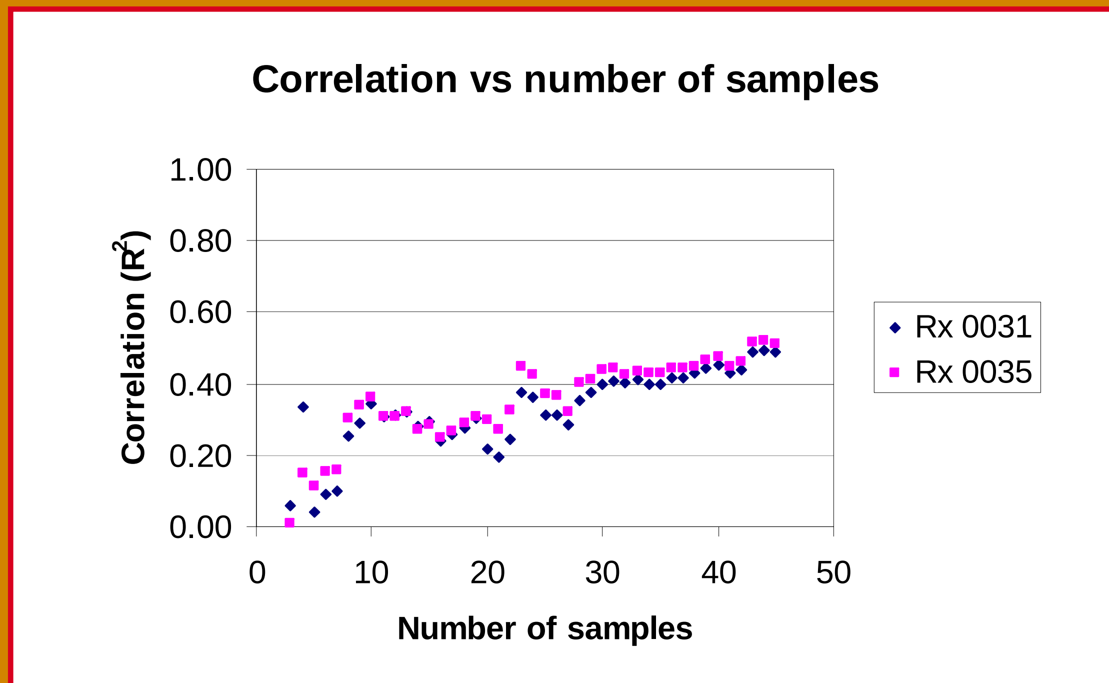
Standing tree sampling – single trees

- Sawlog study – radiata pine
- Correlation between standing tree and log velocity improves as sample intensity increases



Standing Tree >>>>>>> Harvesting Processor >>>>>>> Stem >>>>>>> Log >>>>>>> Log Deck to Mill >>>>>>> Lumber or Veneer

ST300 | PH330 | HM200 | HM200 | LM600 | Grader

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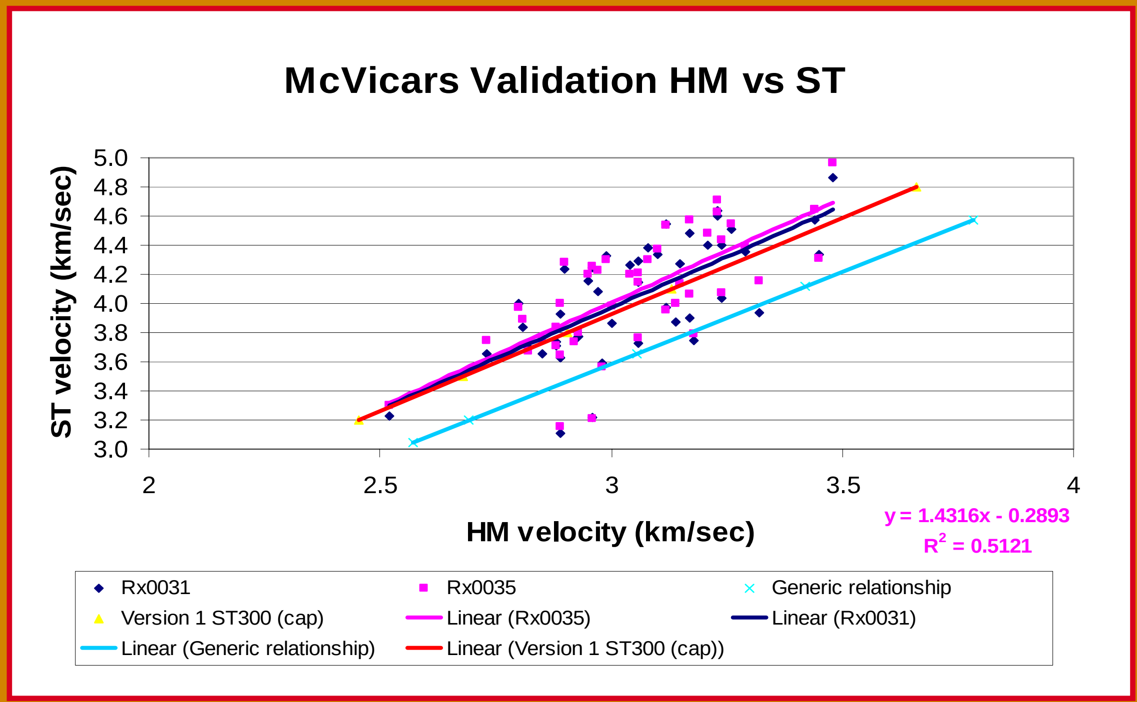
Standing tree sampling – single trees

- Sawlog studies – radiata pine
- ST vs HM relationship is stable, new vs old
- ST velocity is higher than ‘generic’ field oscilloscope based dataset



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Standing tree sampling - stands

- More extensive sampling – large block genetic gain trials
- Stand average measure
  - Cover the stand – plots of 5+ trees
  - Cover diameter range
  - Variability between trees > within
  - Sample as many trees as possible in least time
- 1 set of 10 hits/tree on 50+ trees/stand
- Productivity dependent upon terrain and vegetation

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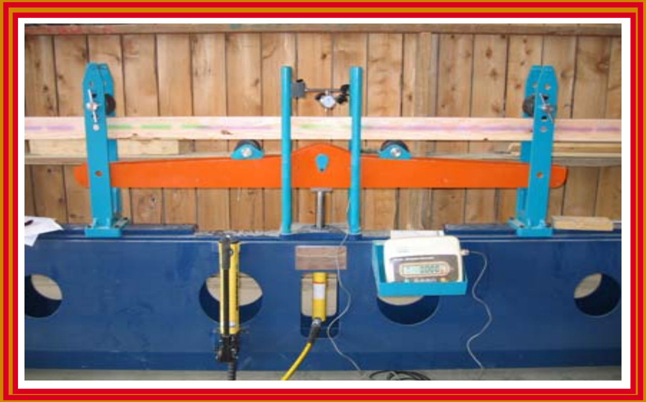
Target Velocities – NZ example

- Dynamic MOE of 8GPa is indicative of VSG8 production and would require
  - Average log velocity 2.8km/sec (allowing 0.1km/sec for SE of mean)
  - Green density 1000kg/m^3
- 8GPa target velocity could vary 2.70 - 3.00 km/sec average
- Equivalent standing tree velocities 3.6 - 4.0 km/sec average at harvest
- Towards end of juvenile wood formation, target 2.8 km/sec although 2.6 may be adequate for structural minimum (5.6 GPa)



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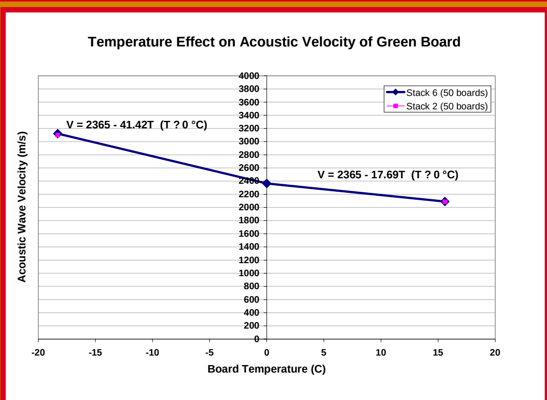
Results – effect of temperature on velocity

In general

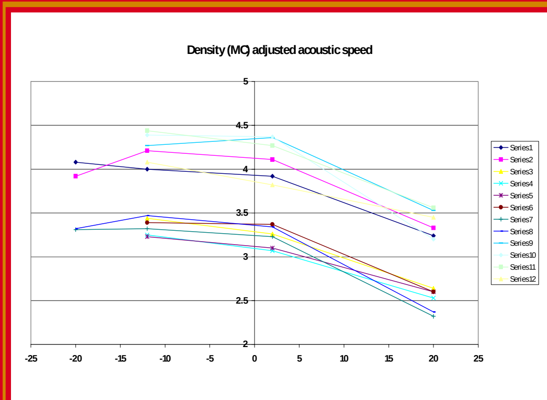
- Acoustic velocity is higher at lower temperatures

But

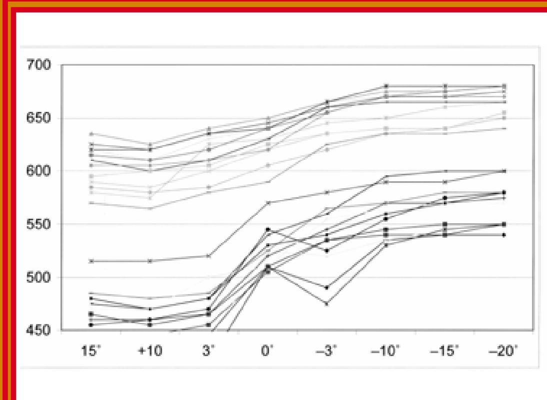
- Rate of change is most significant around freezing
- Moisture content changes may compensate on logs, but not in trees



Source: X Wang, University of Minnesota



Source: P Harris, IRL



Source: L Bjorklund, VMR, SDC

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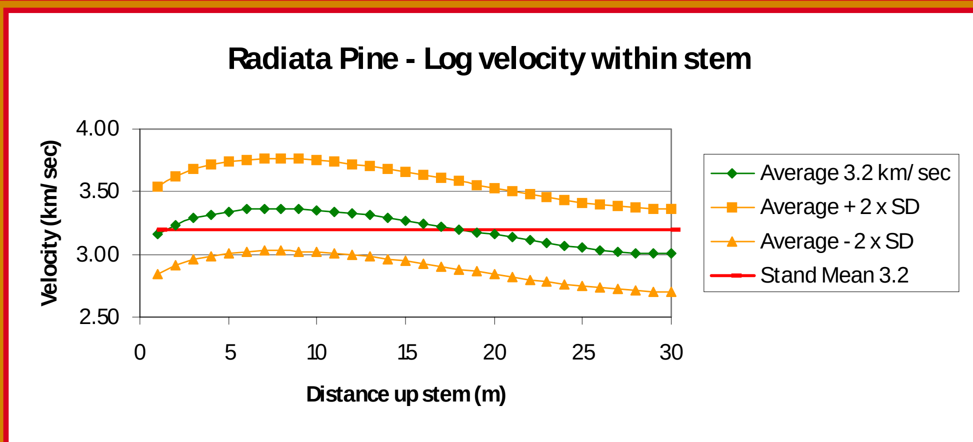
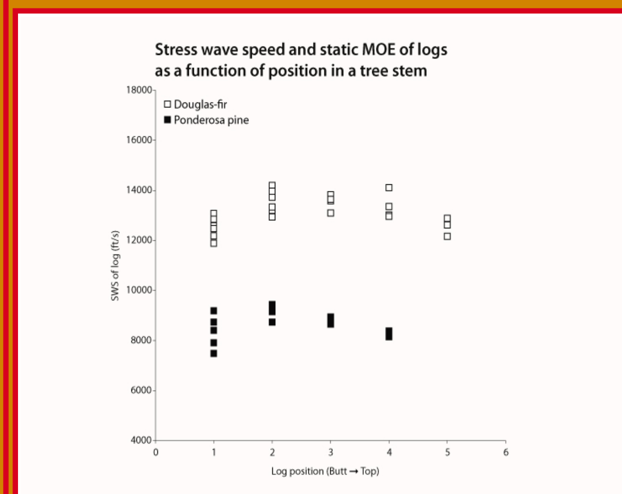
Results –velocity within stem – butt to top

- Acoustic velocity varies from butt to top although greatest variation is between stems
- Highest velocity logs are in mid section of stem
- Variation follows pattern of microfibril angle





Source: X Wang et al, University of Minnesota

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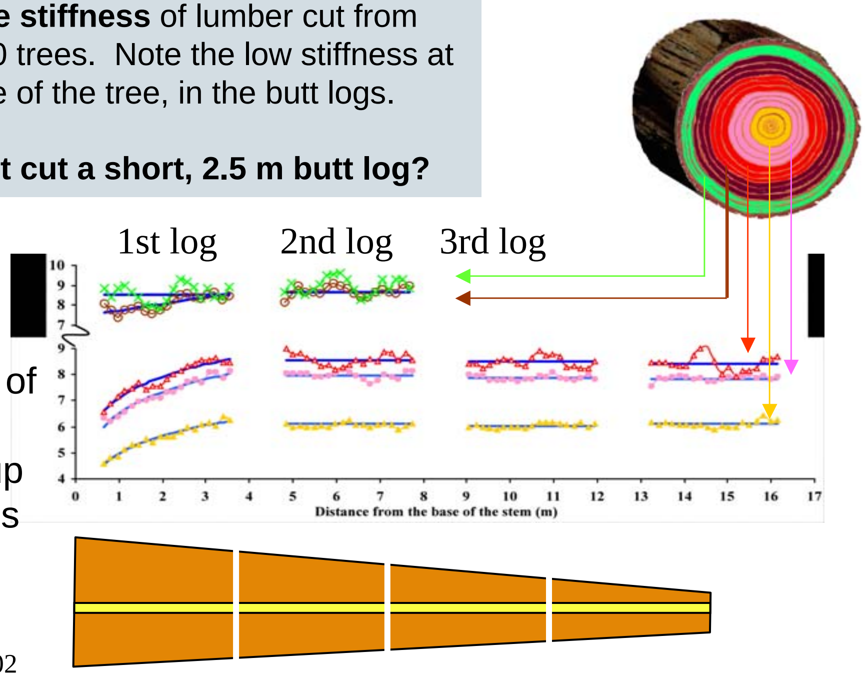
Results – log velocity within stem – pith to bark

Average stiffness of lumber cut from some 60 trees. Note the low stiffness at the base of the tree, in the butt logs.

Why not cut a short, 2.5 m butt log?

Location of boards in the log



Average stiffness of wood in boards up the stems

Ping Xu, 2002

Source: J Walker, University of Canterbury

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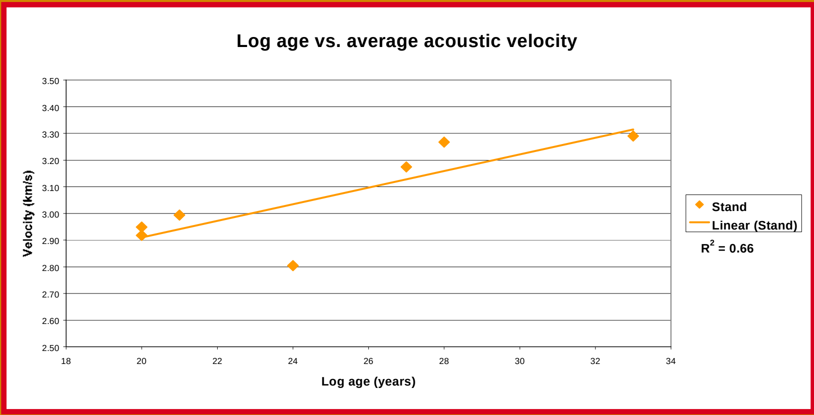
Results – velocity and MoE correlate with age

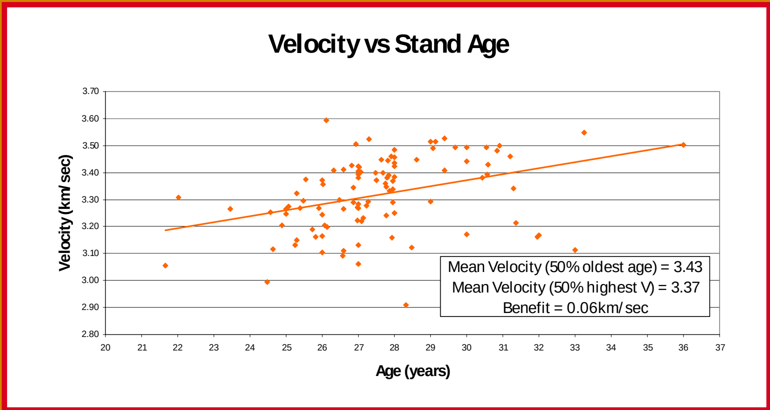
In general

- Acoustic velocity increases with increasing age

But

- Other factors affect velocity and MoE
- Wide range of velocities within stands
- Strategy – set appropriate breeding targets for different ages





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Conclusions

- Highly significant values are at stake
- Variation and heritability are high
- New tools are available that are easy to use, efficient, and precise
- Breeding applications include clonal ranking, progeny trials, and genetic gain studies
- For supporting information

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