Forest Research

Volume or quality? Which way should tree breeding go?

(Part 2)

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Why is quality important?

- Construction is a key market for sawn Sitka spruce timber
- Market acceptance depends on meeting end-user requirements in terms of performance:
  - Strength grading – aim to meet C16
  - Distortion – material meeting requirements of C16 may be rejected due to unacceptable levels of distortion
- Price is also important…

Strength grading

- Strength classes are defined by:
  - Bending strength (lower 5th percentile)
  - Bending stiffness (mean)
  - Density (lower 5th percentile)
- For UK Sitka spruce, stiffness is usually the grade-limiting factor
- To meet the requirements of C16 strength class a mean bending stiffness (Modulus of Elasticity) of 8 kN/mm^2 is needed.
- Where does the UK Sitka spruce resource sit in relation to this?

Stiffness of UK Sitka spruce

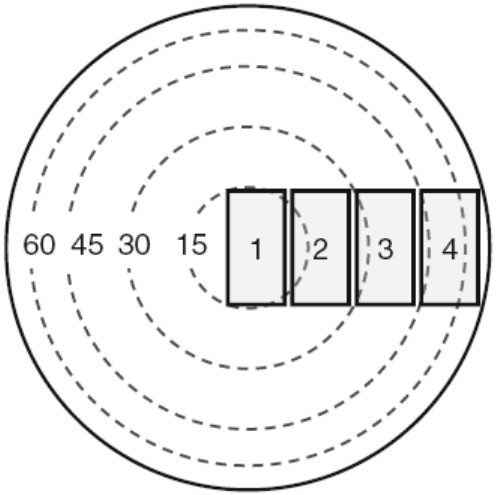
- Kershope trial* – structural timber from QCI + 3 half-sib improved families (37 years old), mean stiffness: 7.9 kN/mm^2 (7.6 – 8.2 kN/mm^2)
- Baronscourt trial† – structural timber from Sitka spruce respacing trial (57 years old):
  - 1.8m x 1.8m: 8.98 kN/mm^2
  - 3.7m x 3.7m: 7.76 kN/mm^2
  - 5.5m x 5.5m: 7.20 kN/mm^2
- Birkley Wood trial‡ – looked at impact of longer rotations: 83 years old

*Moore *et al*. 2009. Effects of genetics on the wood properties of Sitka spruce growing in the UK: bending strength and stiffness of structural timber. Forestry 82, 491–501.

† Moore *et al*. 2009. Effects of early re-spacing on the physical and mechanical properties of Sitka spruce structural timber. Forest Ecology and Management 258, 1174 -1180.

‡ Moore *et al*. 2012. Effects of rotation length on the grade recovery and wood properties of Sitka spruce structural timber grown in Great Britain. Annals of Forest Science, 69 (3), 359-362.

Birkley Wood results



	Radial position					
	1	2	3	4	1 & 2	3 & 4
Stiffness (kN/mm^2)	7.18	9.04	10.08	10.83	8.11	10.45
Strength Class	C14	18	C20	C24	C16	C20

- We are only just “clearing the bar” with Sitka spruce – improvements needed to secure performance
- Improving stiffness is likely to reduce drying distortion too: affected by many of the same factors (mainly related to juvenile wood properties)

‡ Moore *et al*. 2012. Effects of rotation length on the grade recovery and wood properties of Sitka spruce structural timber grown in Great Britain. Annals of Forest Science, 69 (3), 359-362.

Potential for improvement

- PhD at Aberdeen University* investigated potential for improving Sitka spruce mechanical properties through selection
- Tested 20 year-old half-sib trial
- Results:
  - Wood quality traits all moderately heritable, i.e. scope for improvement through breeding
  - Negative correlation between growth rate and stiffness, strength, wood density and microfibril angle
  - BUT some families have superior growth, stem form **and** wood quality traits → breeding from these could offer gains in timber production and performance

*Cameron *et al*. 2012. The potential to improve growth rate and quality traits of stem straightness and branching habit when breeding Picea sitchensis (Bong.) Carr. Annals of Forest Science, 69(3): 363-371 .

Aims of current study

- Aim: assess opportunities for additional screening and selection in the Sitka spruce breeding programme to improve mechanical properties performance
- Objectives:
  - Determine genetic variance components, heritability and breeding values for Sitka spruce wood properties
  - Identify full-sib families that demonstrate superior growth, stem form **and** stiffness
  - Investigate variation in wood properties in clonal trials
  - Test and validate techniques for screening young trees for stiffness

Study sites

- Full-sibling progeny trials, planted in 1985:
  - Strathyre
  - Spadeadam
  - Radnor
- Each site – 63 full-sib families plus QCI and Washington control
- 8 tree plots x 5 replications = 40 trees per family
- Includes 9 families in current commercial breeding population

Non-destructive assessments

- Site details:

Experiment	Elevation (m)	ESC Climate			
		Accumulated Temperature	Continentality	DAMS (exposure)	Moisture Deficit
Radnor 55	360	1252.9	9.0	11.9	89.2
Spadeadam 7	251	1190.6	7.3	15.6	104.5
Strathyre 33	230	1098.5	5.3	16.6	78.8

- 2011 - assessments made on live trees in all families (~2250 trees per site):
  - Diameter (DBH) – all sites
  - Deer damage – Strathyre only
  - Pilodyn pin penetration (for density) – Spadeadam and Radnor
  - Acoustic velocity (for stiffness) – Spadeadam and Radnor

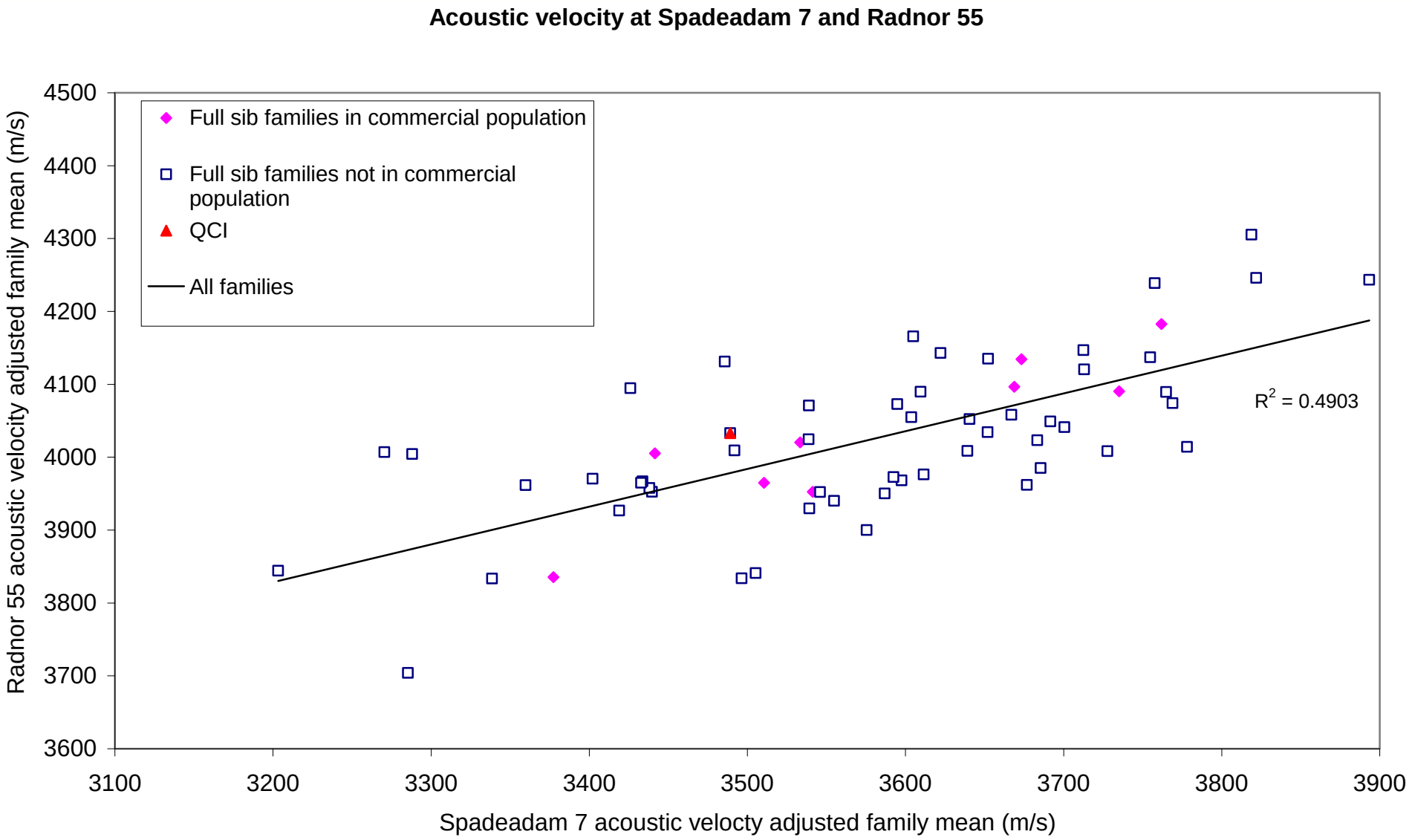
Preliminary results

- Site average and range of family means:

Site	Site Average of Family Means (and range)		
	DBH (cm)	Pilodyn pin penetration (mm)	Acoustic Velocity (m/s)
Spadeadam 7	**18.9** (14.0 - 21.6)	**16.9** (14.0 - 19.2)	**3577** (3203 - 3893)
Radnor 55	**21.7** (16.0 - 29.7)	**16.0** (13.3 - 19.3)	**4024** (3704 - 4305)

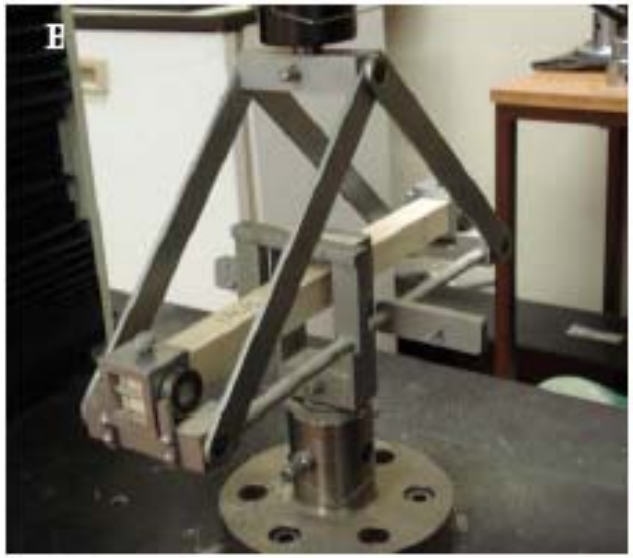
- Mortality: 25% at Radnor, 8% at Spadeadam; possible cause – more vigorous growth at Radnor, increased competition/self-thinning?
- Acoustic velocity higher at Radnor – warmer, more sheltered site at lower latitude

Acoustic velocity across sites



Next steps

- Identify sub-sample of ~15 families for further study
- Destructive sampling and timber testing to analyse mechanical and physical properties – wood density, stiffness, strength (+ possibly grain angle, microfibril angle)
- Determine breeding values for traits of interest
- Selection for further breeding will be informed by results



Photos courtesy of Stuart Kennedy

Early screening for wood stiffness

- Acoustic tools designed for small trees offer the opportunity for earlier screening for wood stiffness in the breeding programme

Photos courtesy of Fakopp Enterprise, Hungary

- Investigating the potential for using these tools in the Sitka spruce breeding programme

Conclusions

- The Sitka spruce breeding programme has delivered gains in timber volume production, stem form and branching
- Improvements in mechanical properties (and perhaps drying distortion) could be achieved by selecting for wood stiffness as well as wood density – we are working towards this
- Portable acoustic tools offer a potential means of screening for wood stiffness in young trees…
- …to inform breeding programme and achieve improvements quickly through controlled pollination and vegetative propagation