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Establishing timber as a prefered material for construction

Variation in the UK Sitka Spruce Resource: The Benchmarking Study

Andrew Lyon, John Moore, Greg Searles, Leena Vihermaa

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SIRT

Strategic Integrated Research in Timber

Why Benchmark the Resource?

Which stand will yield the best structural timber?

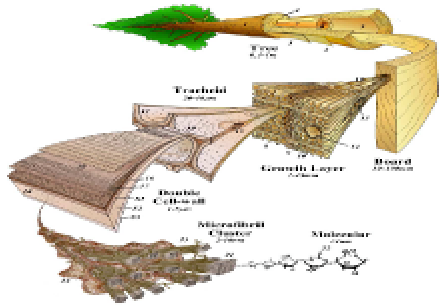
Variation in the Resource

Between Sites

Between Stands

Between Trees

- What are the main drivers of this variation?



Within a Tree

Sources of Variation

There are three main sources of variation:

- Genetics
- Environment
- Silviculture

- This variation affects:
  - Density
  - Microfibral angle (MfA)
  - Knots

Courtesy Dan Ridley-Ellis

Background

- Density and MfA affect the Modulus of Elasticity (MOE)
- Sitka spruce is stiffness (MOE) limited to C16
  - i.e. it usually passes the C24 strength requirement
- This means MOE is the key factor that needs to be understood

Can We Use Historical Information?

- Historical information on timber properties was often not linked to site and stand conditions

- Changes in the resource have occurred in the last 40 years
  - Move to wider initial spacings
  - No-thin management on a number of sites
  - Systematic thinning rather than selective thinning on other sites

- Need to have information that is relevant to the current and future resource

Objectives of the Benchmarking Study

- Obtain information of the variation in physical and mechanical properties of Sitka spruce that are due to differences in environmental characteristics and management regimes.

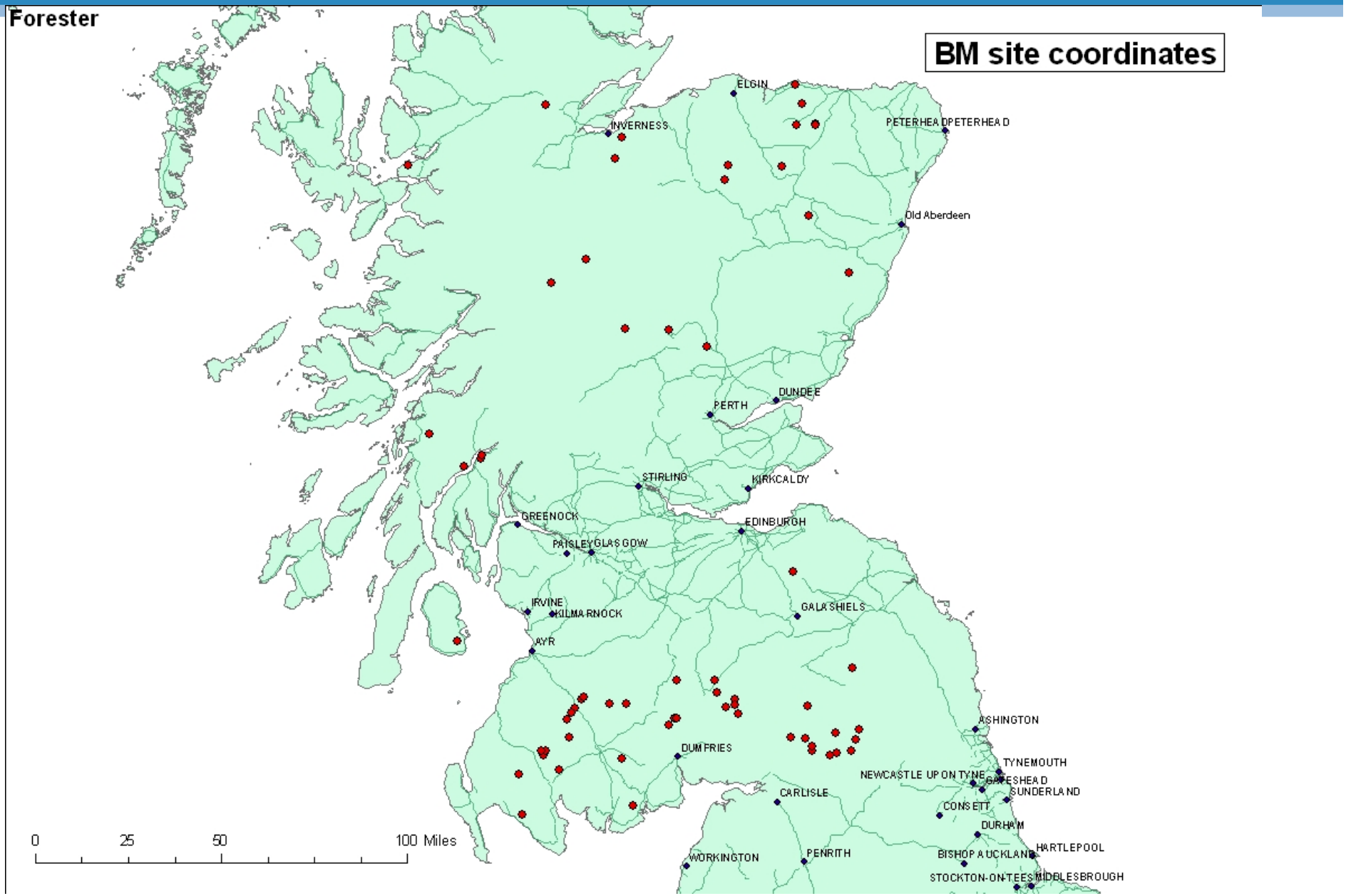
- Test the ability to predict the properties of sawn timber based on standing tree measurements.

- Develop a wood properties map for the UK

Site Selection

- Sites chosen were a subset of sites used in Forest Research's stem straightness surveys
- Sites were selected based on:
  - Elevation
  - Spacing
  - Thinning
  - Yield Class
  - Latitude
  - Longitude
  - Age (35-45 years old)

Benchmarking Sites



Measurements

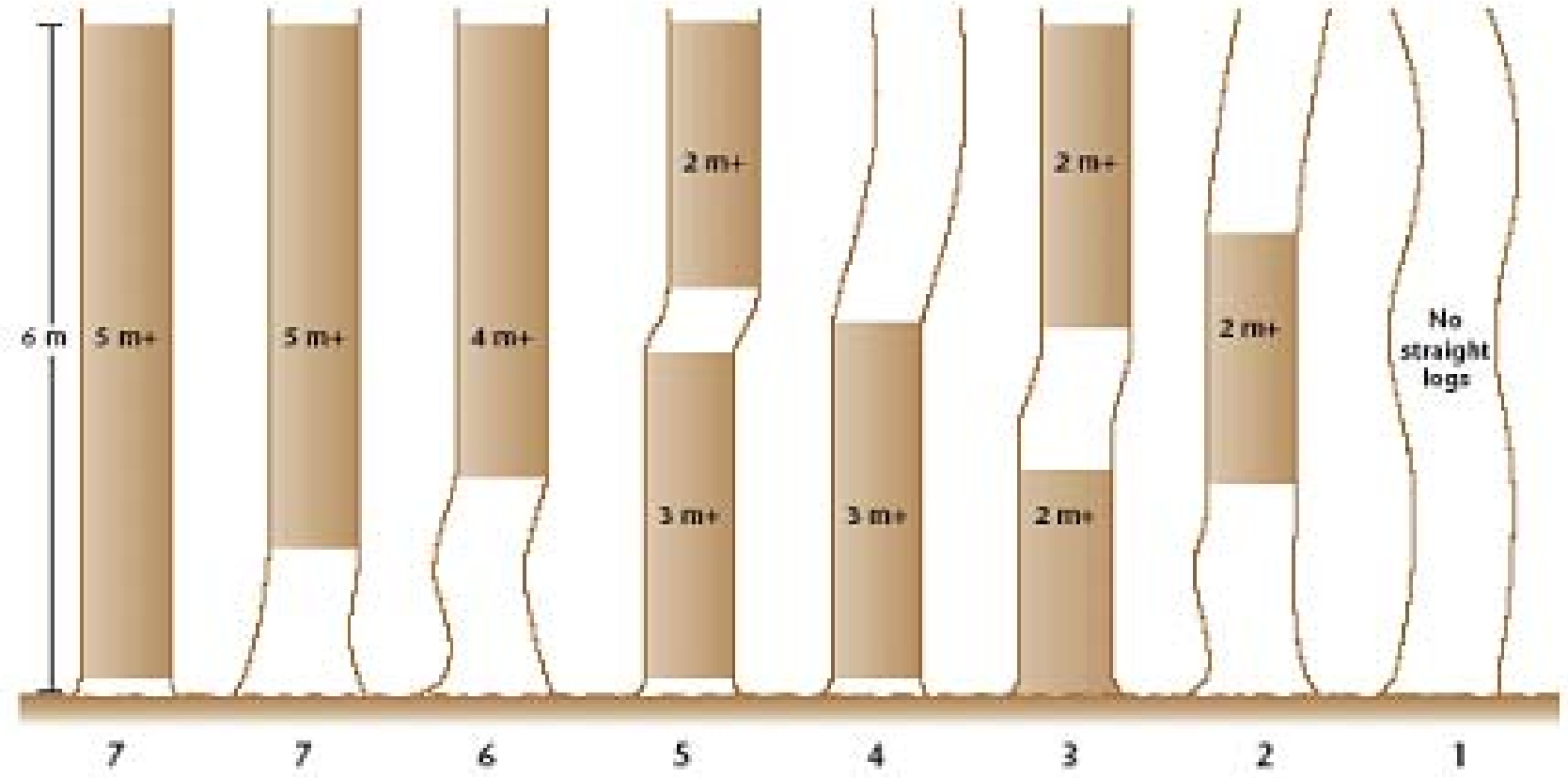
- Standing tree acoustic velocity
- Stem straightness
- Tree size
- Stand density
- Breast height cores

Tree Form

- The following qualitative codes were used to describe various aspects of tree form:

AD	Animal damage
CK	Crook in crown
DL	Double leader
DT	Dead, broken or defective top (e.g. <100mm diam)
FK	Forked – double leader
LN	Leaning tree
MF	Undefined malformation
ML	Multi leader (more than two leader)
RD	Abrupt diameter reduction
RM	Ramicorn branch – results in a spike knot
SC	Scar (from lightning, logging or animal damage)
SW	Sweep
TO	Top out (catastrophic stem break)
UH	Unhealthy

Stem Straightness Assessment



Source: Macdonald et al., 2001. Forestry Commission RIN 39

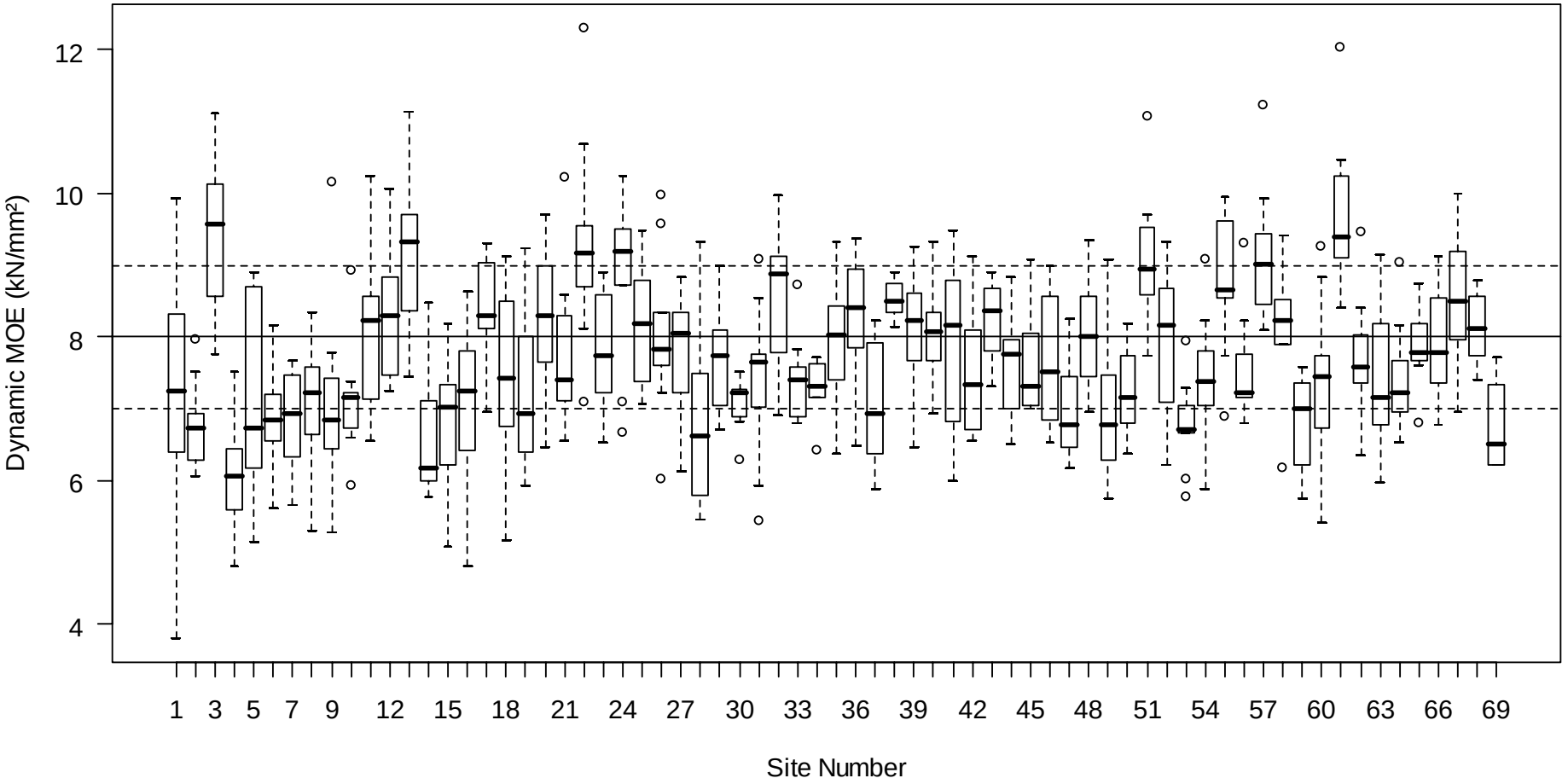
Results – Plot-Level Characteristics

Attribute	Min	Max	Median
Elevation (m)	73	558	272
Yield class	4	20	15
DBH (mm)	141	364	240
Stand density (trees/ha)	500	3000	1400
Mortality (trees/ha)	0	2050	400
Stem straightness	1.3	6.1	3.2
Dynamic MOE (kN/mm^2)	6.09	9.74	7.67

Tree-Level Characteristics

Characteristic	Number of trees
No defects	1388
Ramicorn branches	948
Stem scarring	166
Sweep	132
Unhealthy	120
Forked stem	63
Malformed	55
Leaning	27
Defective top	18

Variation in Dynamic MOE



36% site-to-site, 55% tree-to-tree, 9% within tree

What Factors are Important?

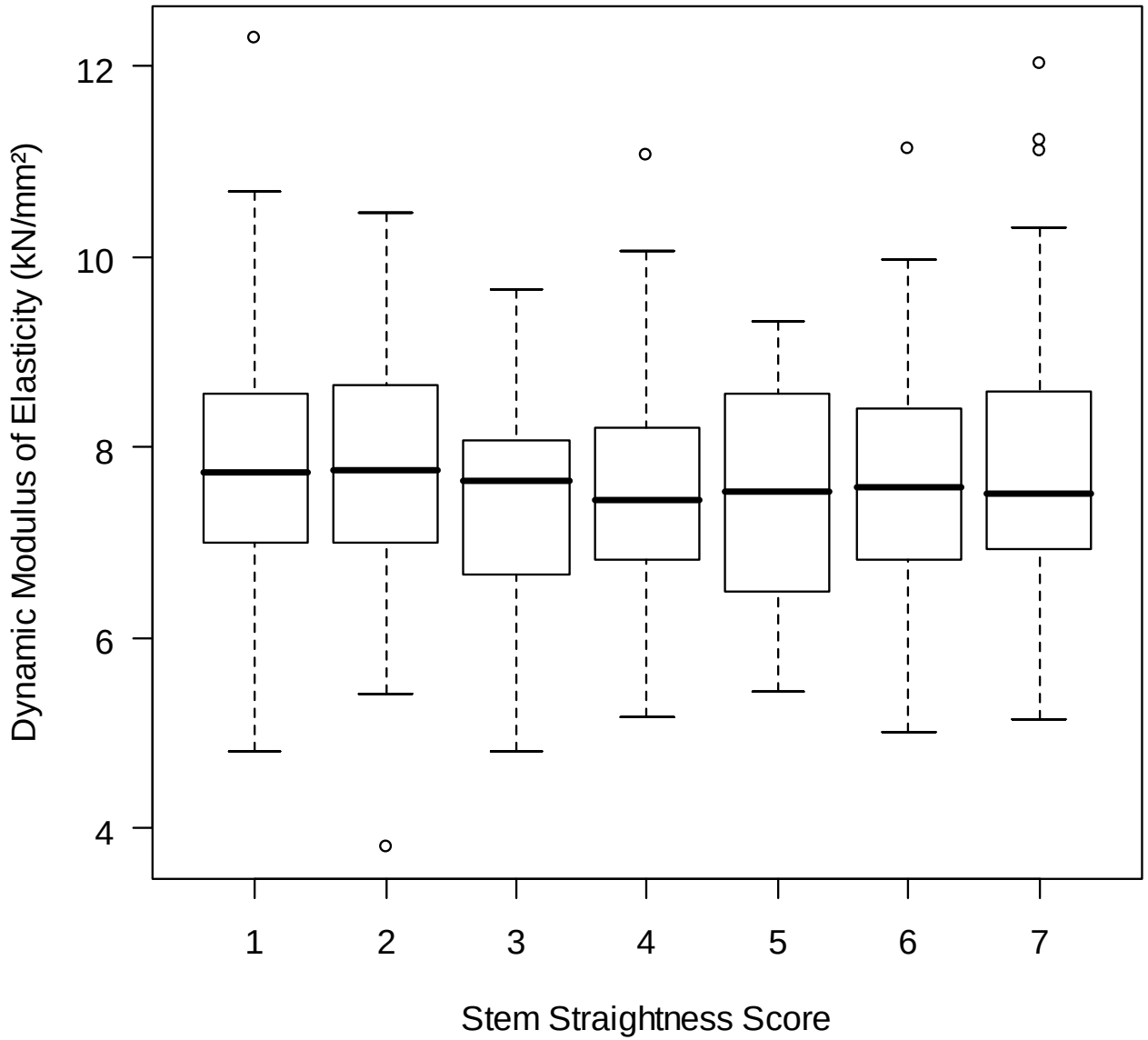
- Single factors
  - Yield class
  - Elevation – very significant
  - Initial spacing – almost significant

- Interactions
  - Elevation x Latitude
  - Longitude x Spacing
  - Elevation x Longitude x Latitude
  - Yield class x Latitude x Spacing

Modelling Site-to-Site Variation in MOE

- A regression model was developed using those factors identified as being significant from the analysis of variance
- The model was able to explain nearly 50 percent of the variation in dynamic MOE
- MOE exhibits the following trends
  - Decreases with increasing yield class
  - Decreases with increasing elevation
  - Decreases with increasing latitude (i.e., distance north)

Is MOE Related to Stem Straightness?

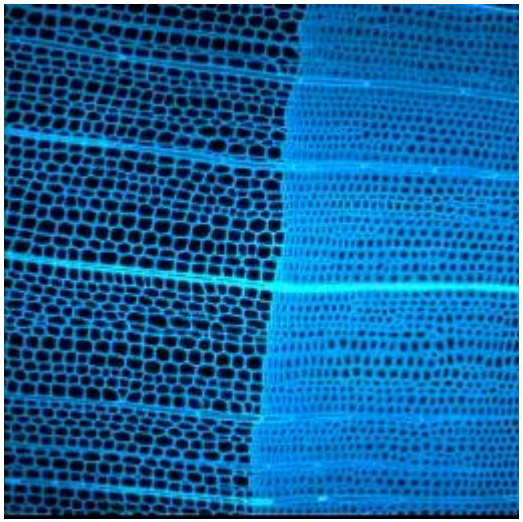


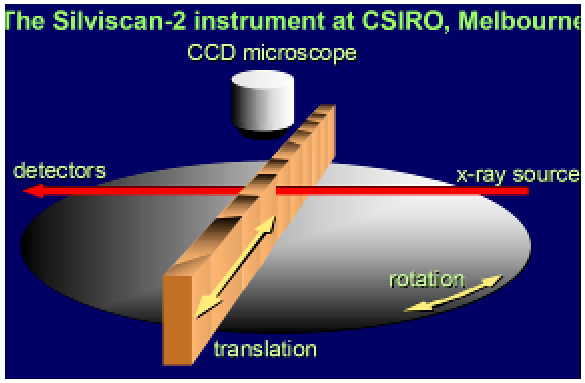
Additional Testing and Analysis

- Obtain additional information about each site
  - Soil type
  - Fertiliser history
  - Seed origin

- Analyse a sub-sample of cores using SilviScan to get microfibril angle, density and MOE
  - Compare with standing tree acoustic measurements

- Wood anatomy
  - Cell wall thickness
  - Lumen diameter





Validation Study

- Based on previous results – 12 stands have been selected for destructive measurement
- Detailed tree and log-level measurements will be made
  - e.g., branch size, taper, log acoustic velocity
- Trees will be felled and a sawing study conducted
- Batten properties will be compared between stands and with standing tree measurements as well as with data from cores

Extension to Other Sites and Species

- Sampling is limited to 64 sites in northern Britain
  - Certain areas are not well represented
    - Kintyre Peninsula
    - Skye, Mull
    - Northern Scotland
  - Extend study to other areas within the UK and Ireland
    - Lake District
    - Wales
    - Welsh Marches
    - Exmoor/Dartmoor
    - Republic of Ireland and Northern Ireland
  - Eventually repeat the study in main conifer species
    - Scots pine
    - Douglas-fir
    - Larch

Additional Related Studies

- Two PhD projects are being undertaken at the University of Glasgow using material sampled from the Benchmarking sites
- Annabelle Caron – extractives in Sitka spruce
- Leena Viherma – environmental influences on wood density

Conclusions

- Considerable amount of variation in wood properties exists
  - A certain proportion appears to be predictable from site and stand factors
  - Further refinement of models is required
    - Mapping of wood stiffness could be possible
  - Validation of the results through a sawing study will allow sawn timber properties to be related to standing tree measurements

- Extension to other sites will allow a greater range of variation to be captured
  - Latitudinal effects should show through more strongly