Linking growth and quality models with terrestrial and airborne scanning to predict the quality of the British forest resource

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Outline of Talk

• Some Issues about British Grown Timber
• Aims and Approach to Timber Quality Modelling
• Field Data Collection & Properties Modelled
• Timber Quality Model & Links to Growth Model
• Use of Airborne/Terrestrial Laser Scanning
• Aberfoyle Trial & Results
• Conclusions
From 1950-1980, plantings moved to wider spacing, more exposed sites with fertiliser application. This raised concerns about the future quality of timber from the stands.

Breeding programmes have favoured tree vigour and form but tended to neglect important wood characteristics (e.g. wood density, juvenile wood, microfibril angle, MoE).

Recent focus on Continuous Cover Forestry (CCF) is raising concerns about future timber quality from such stands.

It is becoming increasingly important that timber quality is incorporated into future production forecasts in Britain.
Timber Quality Programme in Great Britain

• To investigate and model the effects of silvicultural practices, site factors and genetics on timber quality

• To develop methods of assessing and forecasting timber quality on standing trees

• To provide improved information about the quality of future timber supplies to forest managers and wood based industries
Modelling Approach

Integrated approach, aimed at linking models & measurements in a DSS

Ecological Site Classification

Growth Models

Stem Straightness

Timber Properties Model

ST 300 Acoustic Tool

HM200 Acoustic Tool

Batten Performance Models
Field Data Collection

Our field activities include:

1. Tree felling for ground measurements
2. Measurement of branch sizes, and stem taper on felled tree
3. Use of stem straightness scoring
4. Discs for laboratory work
5. Acoustic testing on standing tree
Laboratory Measurements

- SilviScan Operation (Evans 2001)
- Density Measurement with CT Scanner
- Mechanically testing for Strength & Stiffness
- Grain Angle Measurement
- Microfibril Angle (Evans 1999b in McLean 2007)
Timber Quality Model

- A Timber Quality Model has been developed for Sitka spruce (*Picea sitchensis*) with three main aims:
  - To assess the quality of the existing Sitka spruce resource, based on inventory data
  - To predict effect of various silvicultural regimes & management practices on timber properties and end-use quality
  - To estimate the effect of genetic gains from tree breeding upon timber properties and log outturn
Linking Models with Lidar Measurements

Properties Modelled

Stem Profile (Taper)

Wood Density Profile

Branch Diameter Profile

MfA Variation

Ring Width Variation

Spiral Angle Variation
Timber Quality Model is linked to the Growth models based on Yield Models (Tables) by Edwards & Christie (1981).

To run the model for a given stand, a yield class is specified, with a thinning regime, stand age, and initial spacing.

Given the initial inputs, a specific Yield Table is identified & accessed; top height and mean diameter (dbh) are read from the yield table, and mean tree height is derived from top height;

These values (dbh & Ht) are then used as inputs into a taper function which specifies an average stem profile for the mean tree in the stand, which forms the basis of growth ring and density profile models.
Linking Models with Lidar Measurements

Terrestrial Laser Scanner
Stem Point Cloud
Linking Models with Lidar Measurements
Linking Models with Lidar Measurements

- DBH
- Height
- Angle
- X-Pos
- Distance
- Y-Pos
- Basal Area
- Taper Prediction
- Tree Height to 7cm
- Tree Position
- 5 M
- 15 M
- 10 m
- 10"
Airborne LIDAR
Measured-range interpretation of tree canopies
Linking Models with Lidar Measurements
Aberfoyle Trial

Location of Aberfoyle Forest in Scotland
Aim of study was to investigate the possibility of extracting forest information from Lidar measurements & to use them as inputs into growth and timber quality models

Lidar surveys were undertaken in 2002 and 2006 (&2008) and data analysed to provide estimates for top height, individual tree heights, crown width and tree diameters

Tree diameters, heights & stem straightness were measured in sample plots

Increment cores were extracted from 43 sample trees and analysed for wood density & MfA using Silviscan

Comparisons were then made between predicted values from TQ Model (Lidar simulations) and Silviscan values (used as standard)
Linking Models with Lidar Measurements

Canopy Delineation
Height Estimation
Diameter Estimation
Modelling Height using field data

Estimation of tree heights with LIDAR

\[ y = 0.9994x \]

\[ R^2 = 0.9583 \]
Modelling DBH using field data

Estimations of DBH from LiDAR

\[ y = 0.8071x + 7.4333 \]

\[ R^2 = 0.8828 \]
Linking Models with Lidar Measurements

Aberfoyle plot 2
2002
Canopy delineation
Extract tree height and dbh
Input to TQ model
Results: Wood Density

- Results obtained indicate that mean wood density is overestimated in both plots, with errors between 10% (for plot 5) and 11% (for plot 8).

- Density distribution plots indicate a wider spread of the values for measured density than predicted values.

- Statistical tests indicated that the differences obtained are all highly significant ($p<0.001$).
Results: MFA

- Results for MfA indicate that mean MFA is underestimated in both plots; with errors rising to about -27% (plot 5).

- Distribution plots indicate a wider spread for measured MfA than predicted.

- Statistical tests indicated that the differences obtained are all highly significant ($p<0.001$).
Predicted values for mean stem straightness scores were very close to field estimated values for both plots.
Discussion and Conclusion

- While measured and predicted wood density and MfA values are shown to be significantly different, it is difficult to attribute the differences to any particular cause.
- The differences could be due to the quality of input data used (Lidar estimates) or to the behaviour and performance of sub-models embedded in the timber quality model, or both.
- Problems with simple Yield Models available, which only deal with mean tree. Now trying to calibrate TASS/TIPSY & MOSES individual tree models for Britain.
- It is most probable that some biological and environmental factors, not included in the models, constitute a source of variation.
- Ongoing research is taking account of this by sampling across a wide range of sites in Britain, so that more complex and robust mixed-type models can be developed to incorporate both site to site, and tree to tree variability.
- At the same time Airborne Laser Scanning (ALS) and Terrestrial Laser Scanning (TLS) research continues on the study site to improve the derivation of tree parameters.
- These research activities should lead to improved models and data collection methods.
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