Forest Research

Timber Quality Assessment

Barry Gardiner and Shaun Mochan
Forest Research

with thanks to Elspeth Macdonald, Dave Auty, John Moore, Alexis Achim

Improved Conifer Timber Quality through Plant Selection and Silviculture
Dunkeld, 11 February 2009
FC Scotland Timber Development Programme

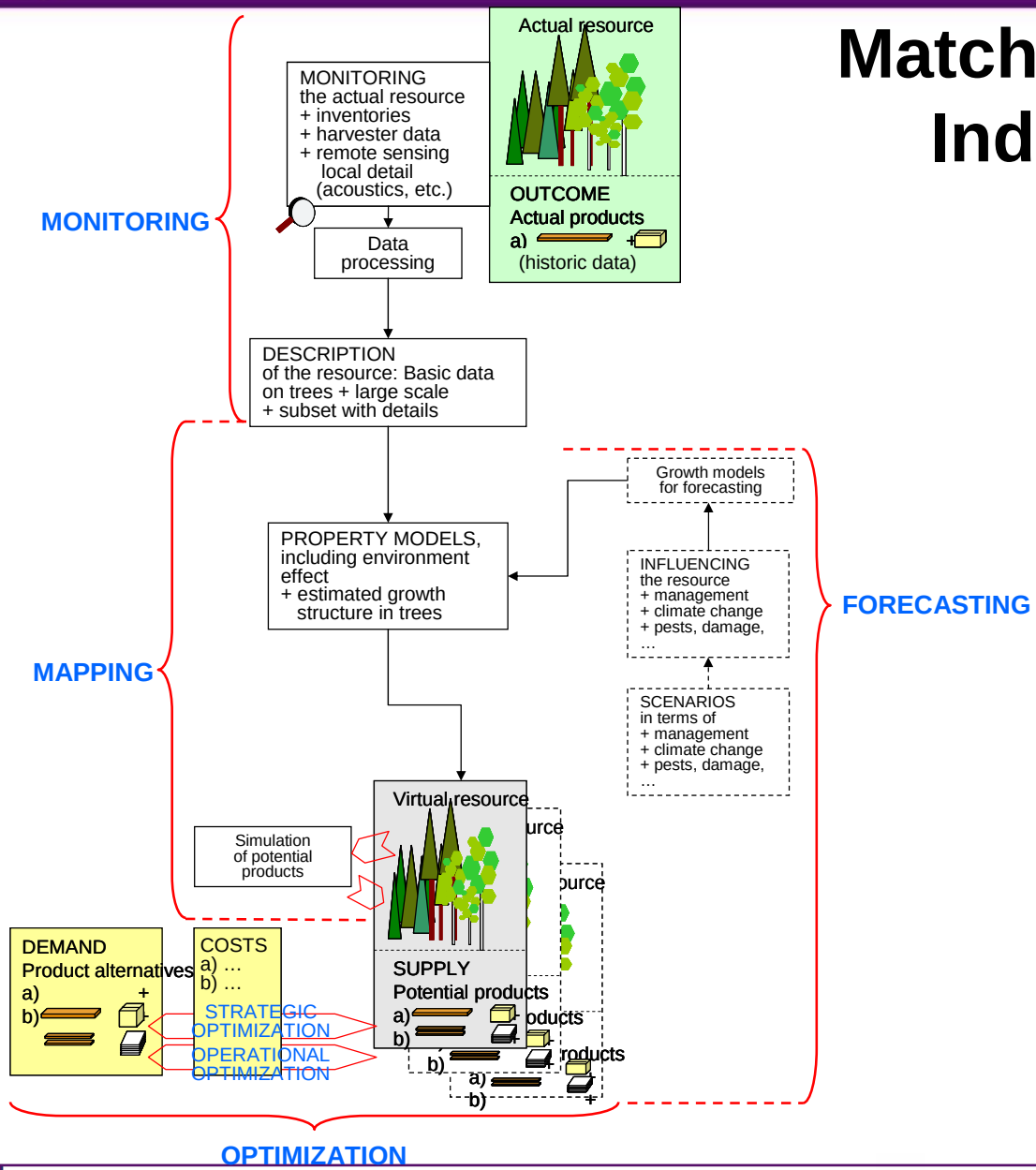
Part 1: Structure of Talk

- Why?
  - Discussion of the benefits of measuring timber quality in the field
- How?
  - Description of the methods available to measure timber quality
  - Standing trees/logs
- What?
  - Discussion of what different measurements tell us about the forest resource
- When and Where?
  - Practicalities of incorporating timber quality measurements into forest operations

Why Measure Timber Quality?

- Just knowing quantity is no longer enough
- Increasing need to match resource to industry requirements
- Help ensure “right” material goes to the “right” end-use
- Measurement can enhance (or at least maintain) value for seller
- Help removes risk to purchaser
- The industry needs to move towards the concept of “precision forestry”
  - *“Precision forestry uses high technology sensing and analytical tools to support site-specific, economic, environmental, and sustainable decision-making for the forestry sector supporting the forestry value chain from bare land to the customer buying a sheet of paper or board."*

Matching the Resource to Industry Requirements



Part 2: Recoverable Volume

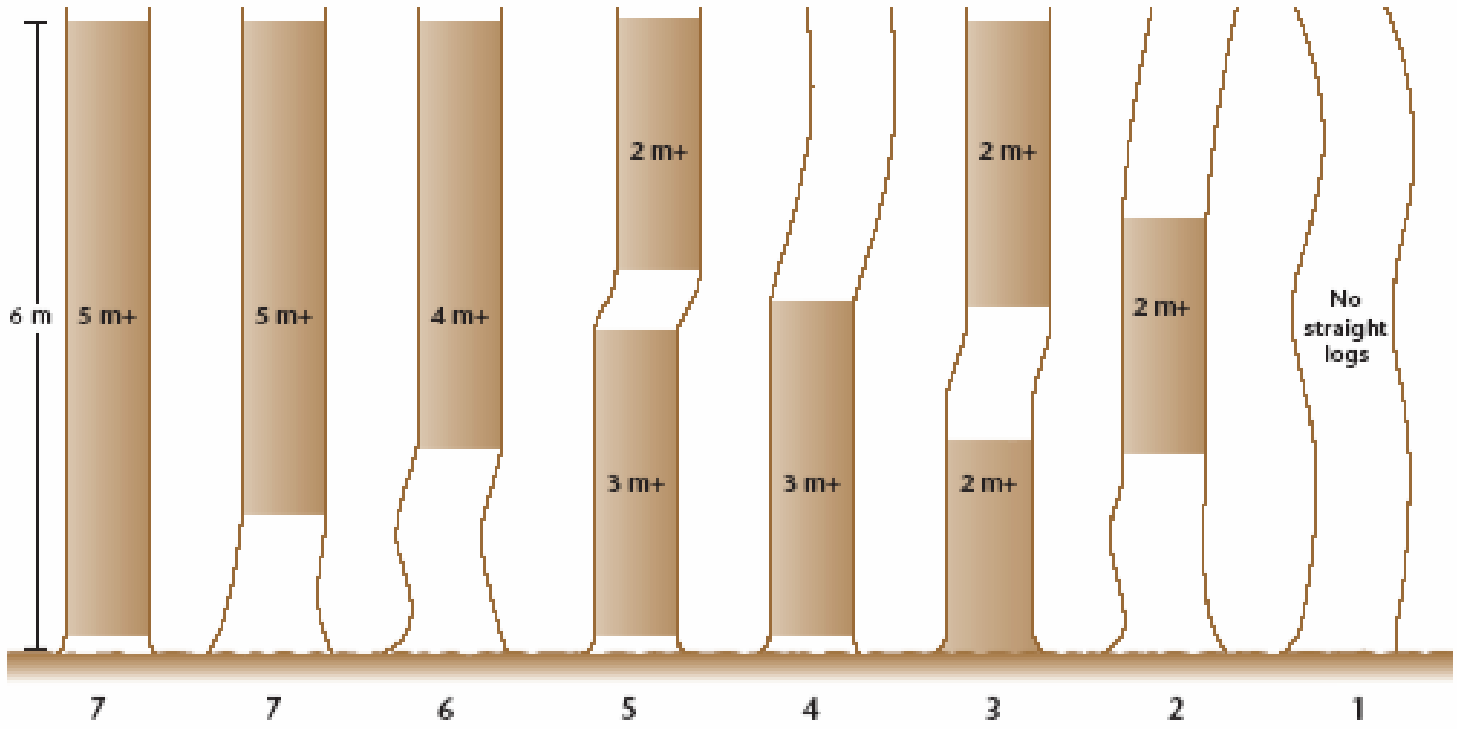
- Just measuring the volume of a tree doesn't tell us what mix of products is available
- Need tools to predict product assortments
- Need measurement of factors that affect this product assortment
- Key factors are:
  - Tree size
  - Taper
  - Straightness
  - Knot size

Tools to Measure Recoverable Volume

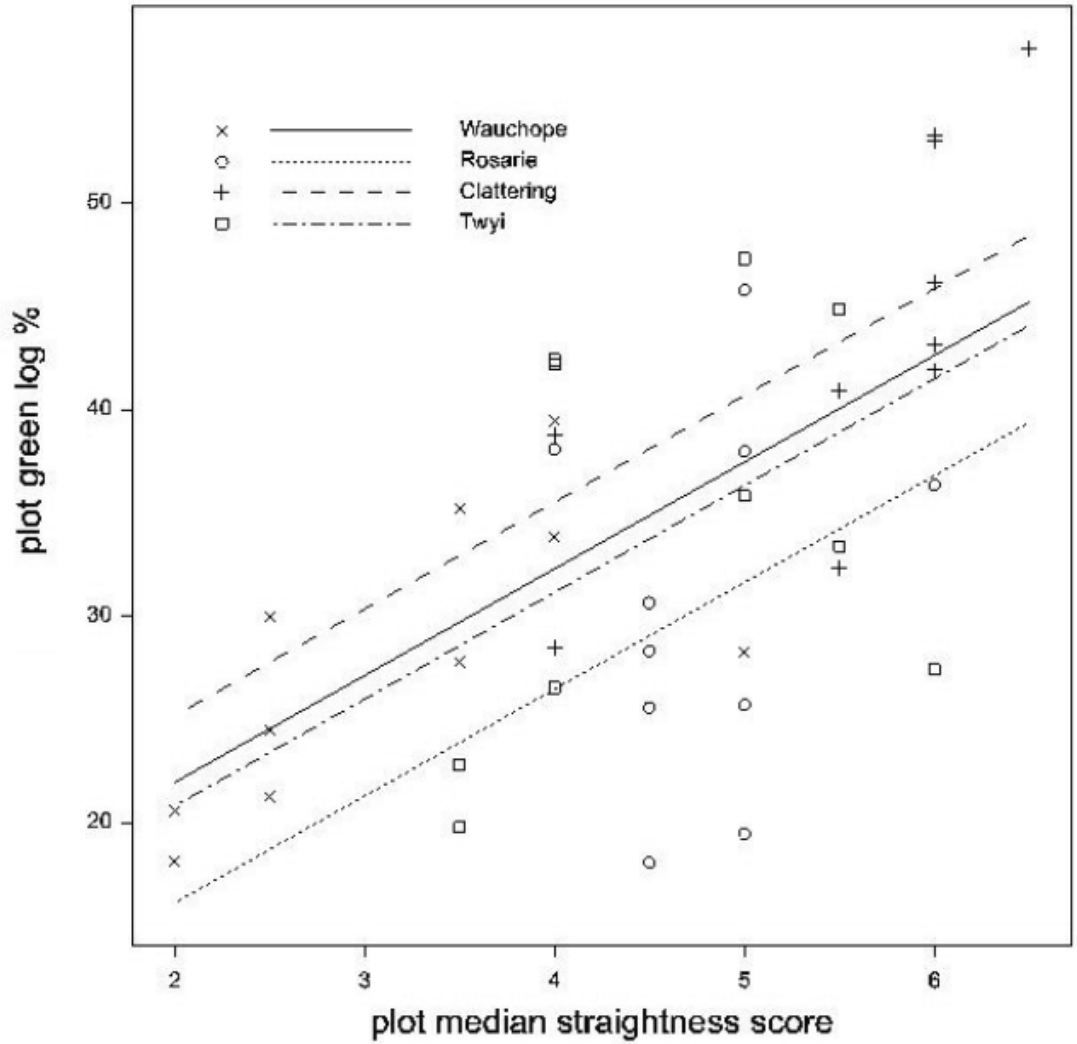
- Stem straightness assessment method
- Measurement of “height of lowest dead branch”
- Terrestrial laser scanners (TLS)
- LiDAR

Stem Straightness Scoring

- System developed for use in Sitka spruce
- Can be used to predict out-turn of “green” logs



Green Log % versus Median Straightness Score



Branching Indices

- Height of lowest dead branch commonly used as branching index in Scandinavia
- Can be estimated visually or measured with hypsometer
- GL% = 8.617 + s + 3.478h

  GL% = proportion of green log volume

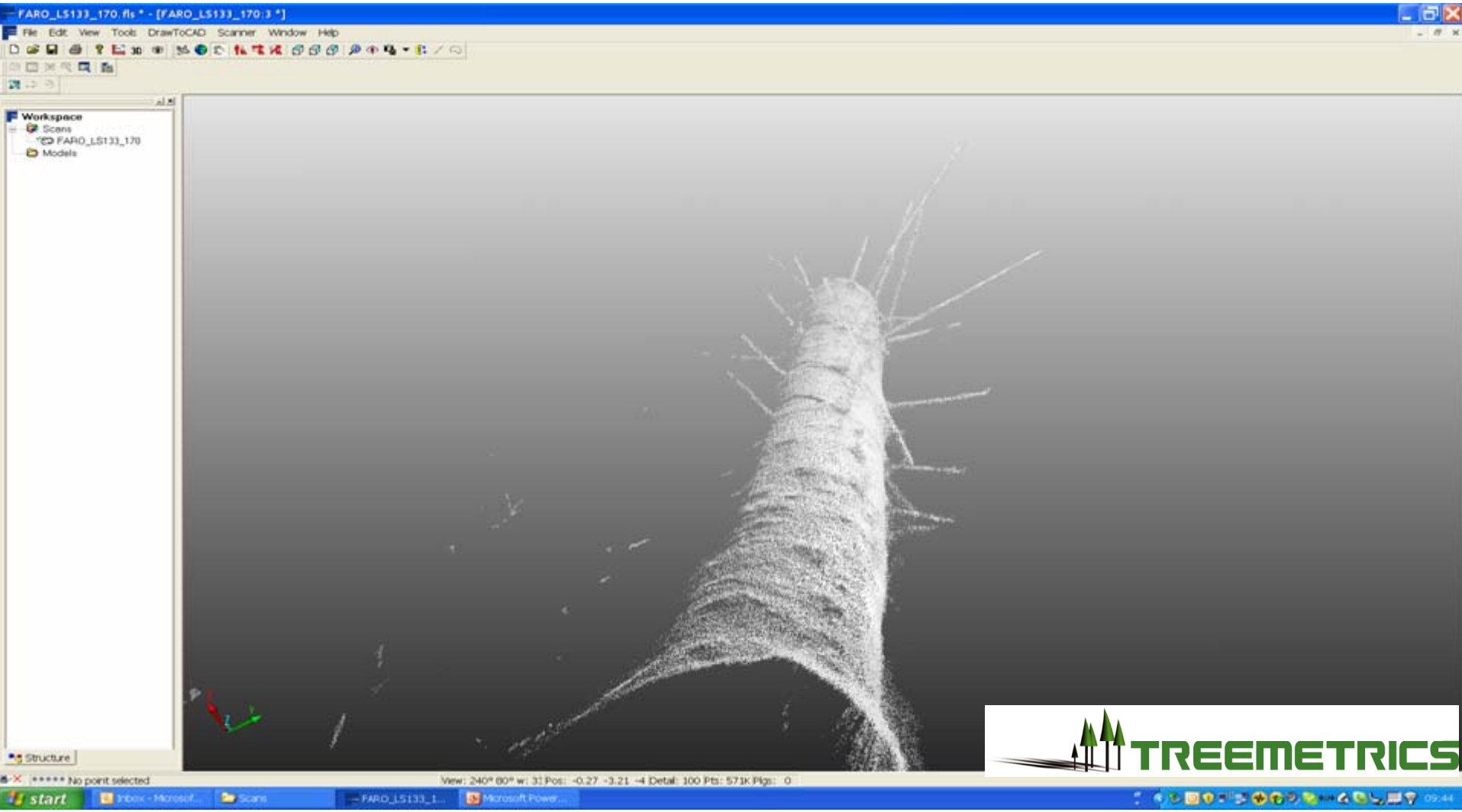
  s = fixed effect for straightness score (1=0, 2=11.66, 3=17.44, 4=22.71, 5=25.74, 6=40.60 and 7=44.20)

  h = height of lowest dead branch

  R^2 = 0.49

Terrestrial Laser Scanner

Stem Point Cloud



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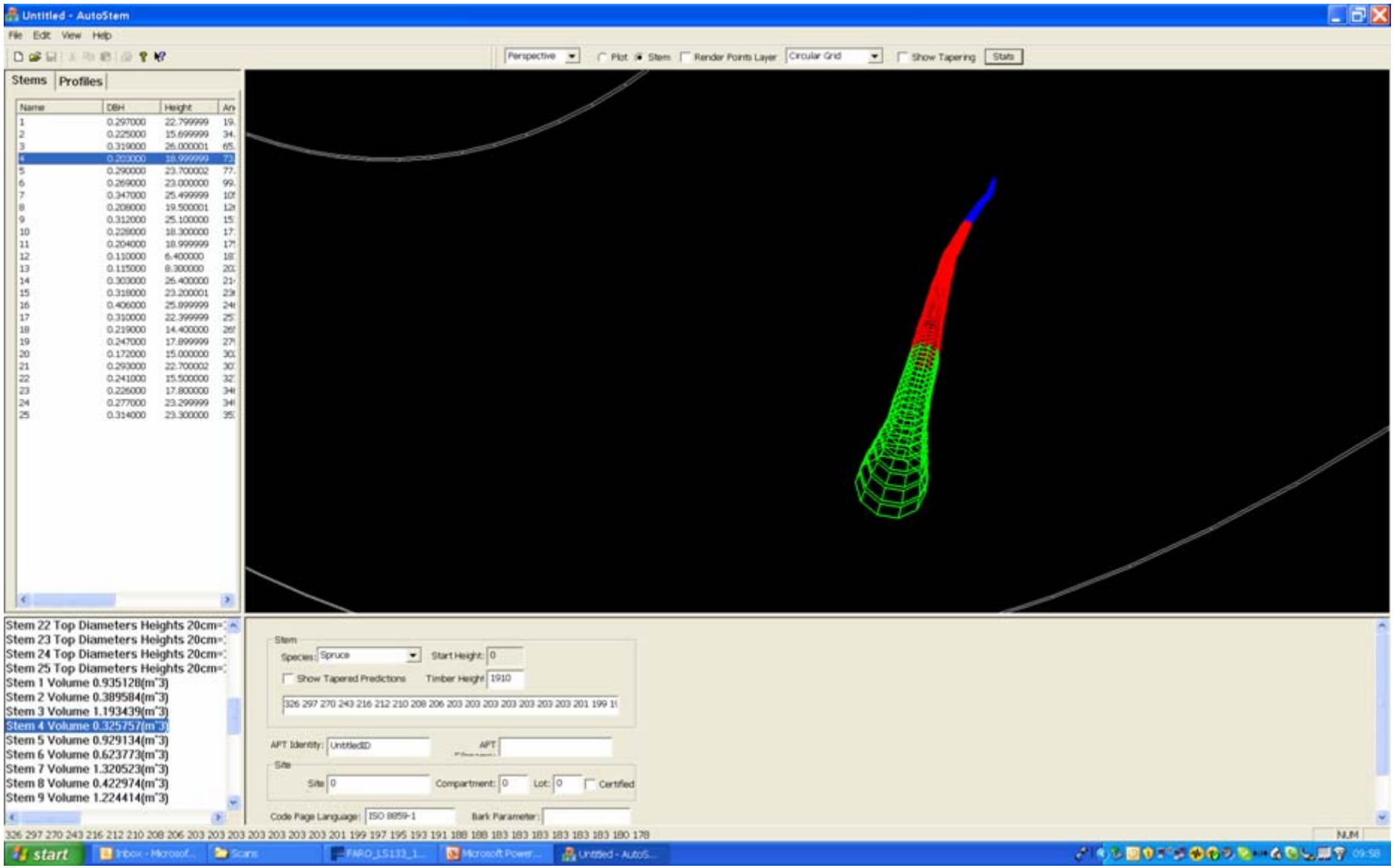

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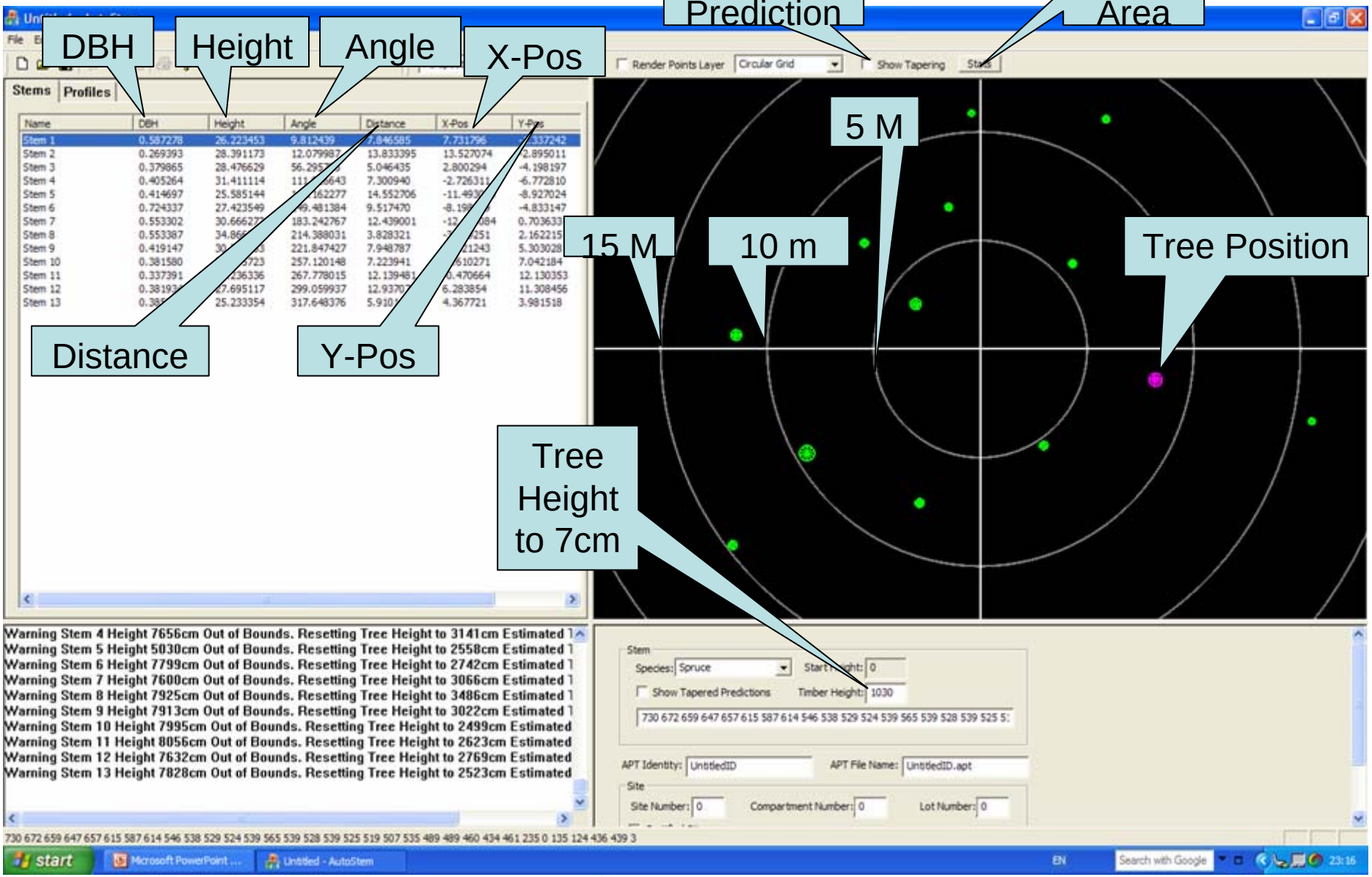
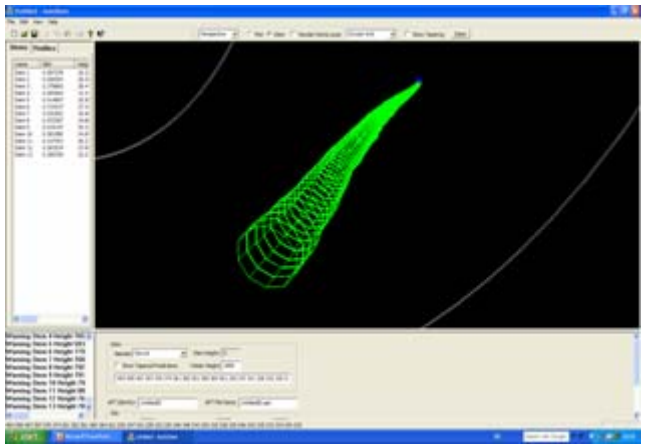


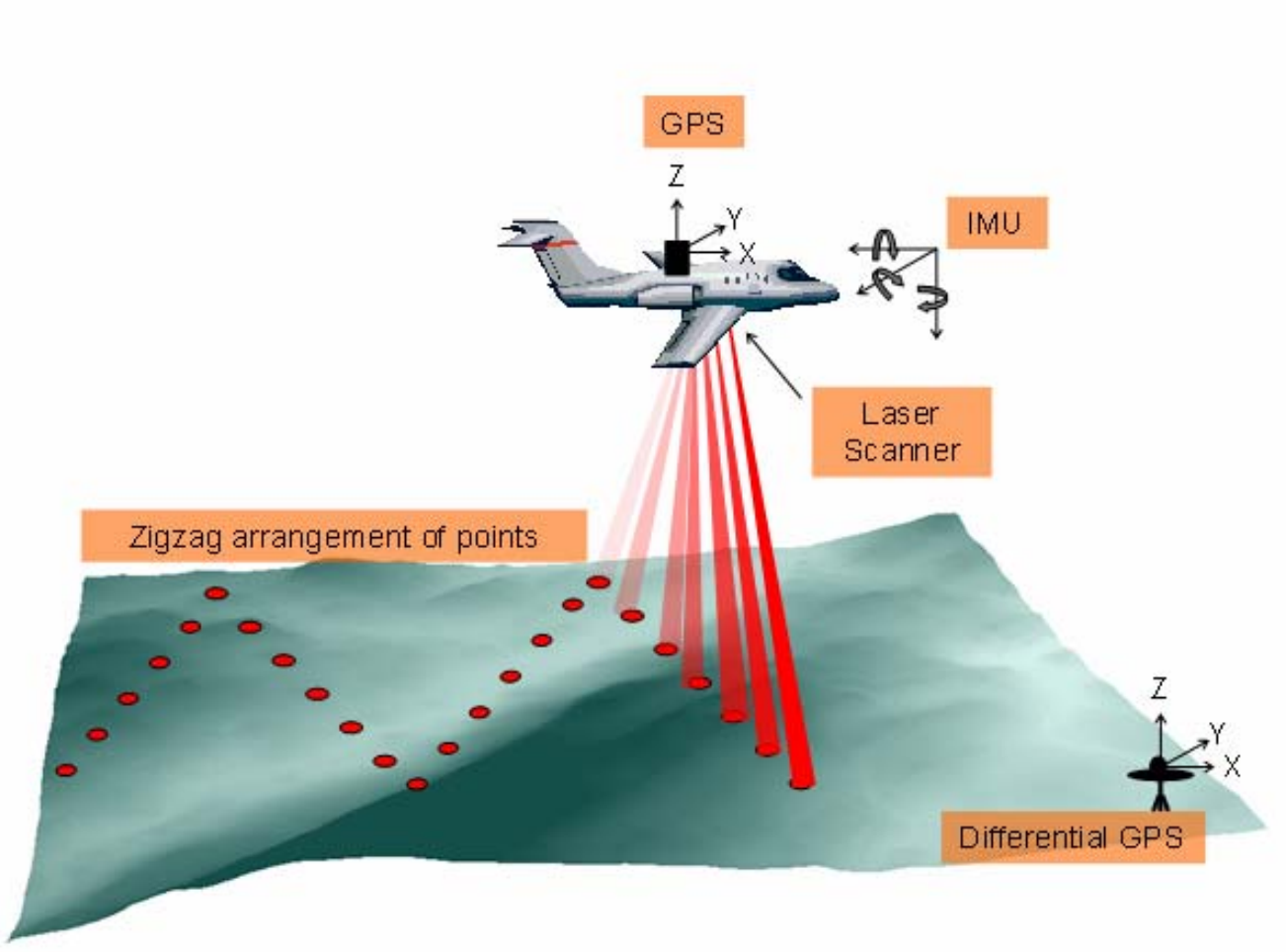
Improving Value Recovery



AutoStem Harvest Solution

Airborne LIDAR

Measured-range interpretation of tree canopies



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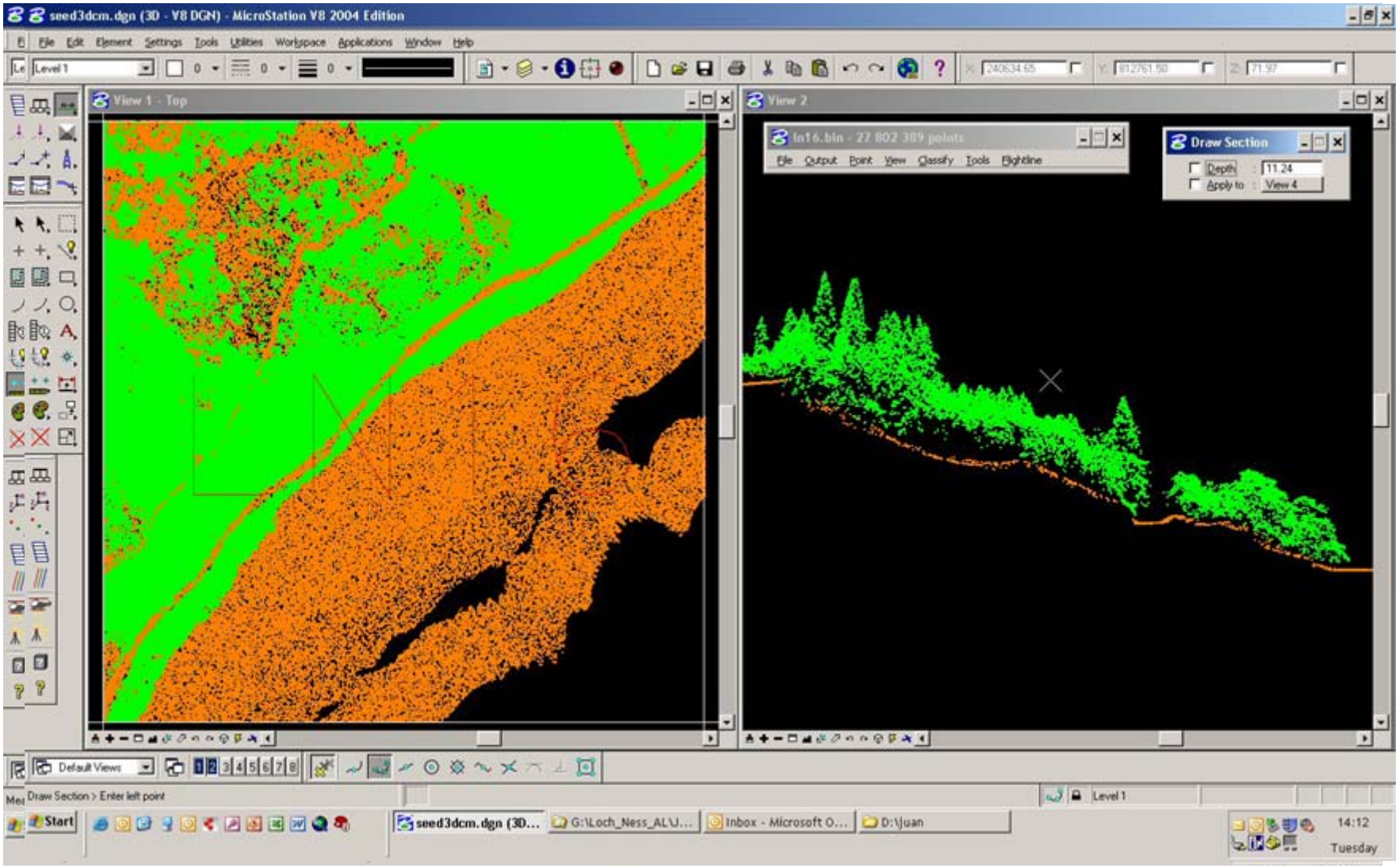


Part 3: Mechanical Stiffness of Timber

- Tools for predicting recoverable volume tell us nothing about performance of final product
- Mechanical stiffness is best measure of final performance of sawn timber
- Acoustic tools allow non-destructive measurement of mechanical stiffness and grade outturn

Tools to Measure Mechanical Stiffness

- Standing Tree/Harvester Acoustic Tools
- Log Acoustic Tools
- In-line Acoustic Tools

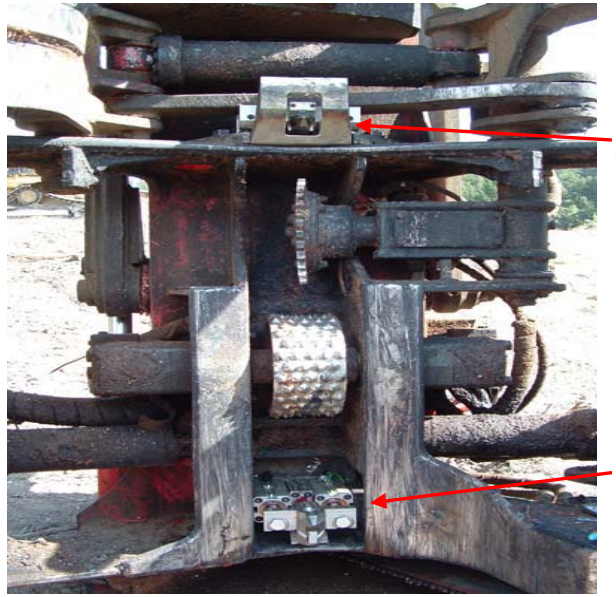
Stand → Road side → Sawmill

Tree level - ST300

Log level - HM200

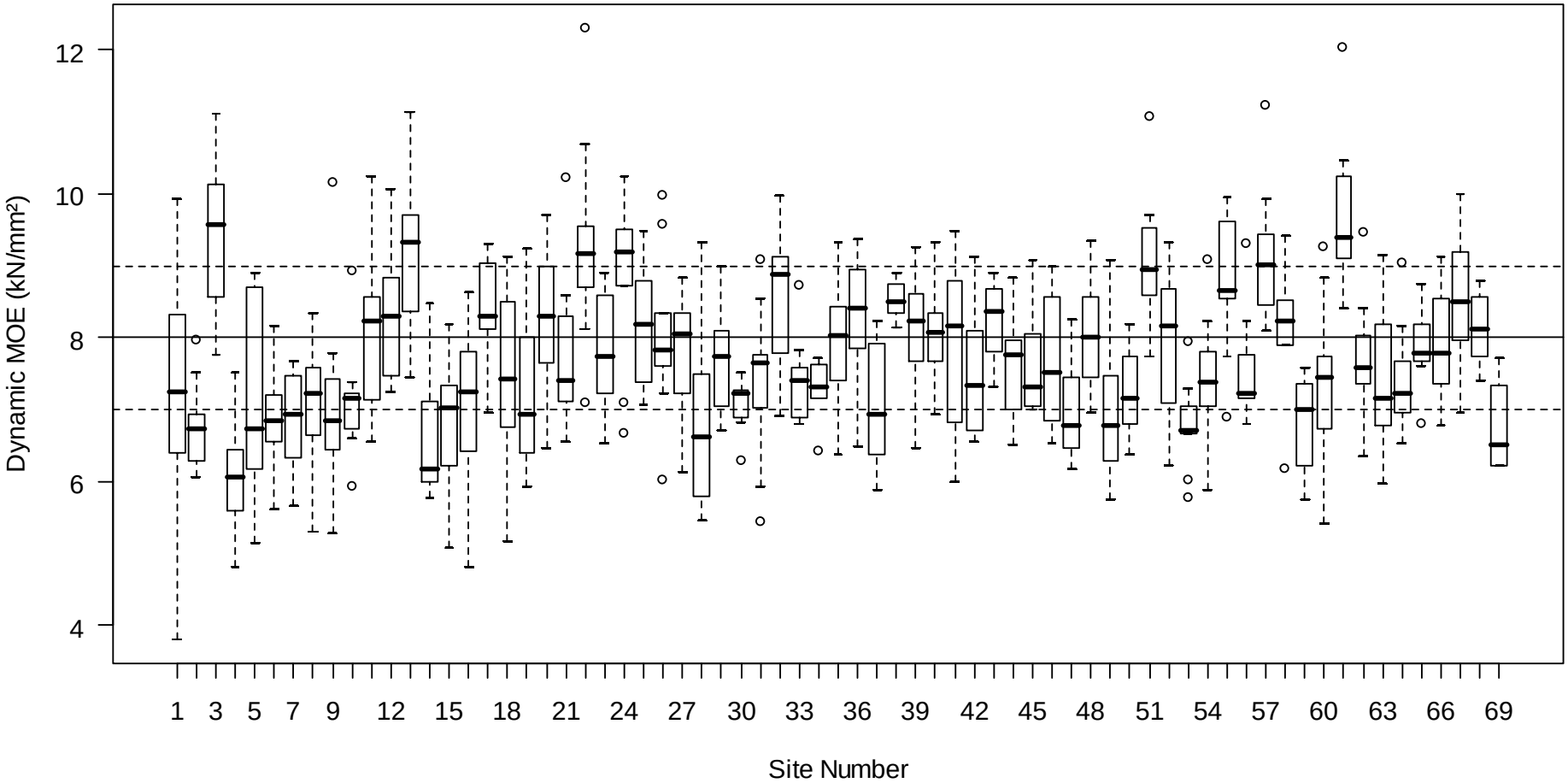
Timber Quality Assessment

- Prototype Acoustic Tool on Harvester Head (PH330)



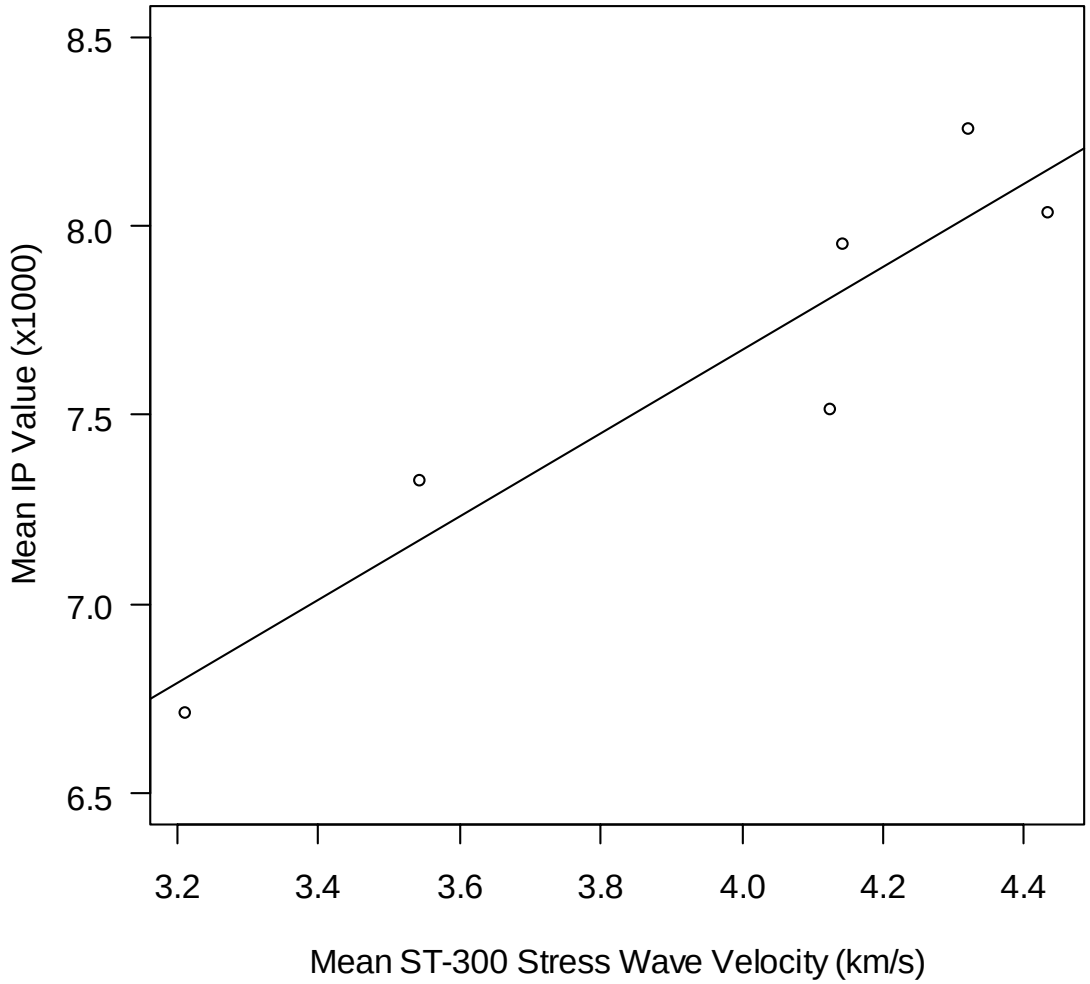
- Operation Acoustic Tool on In-feed to Sawline (LM600)

Variation in Dynamic MOE in Scotland and N. England *(courtesy Napier University)*



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

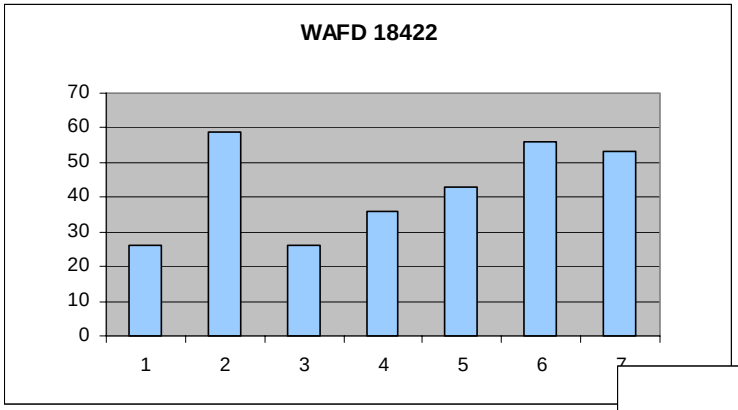
Correlation between ST-300 Acoustic Measurement and IP from Grading Machine

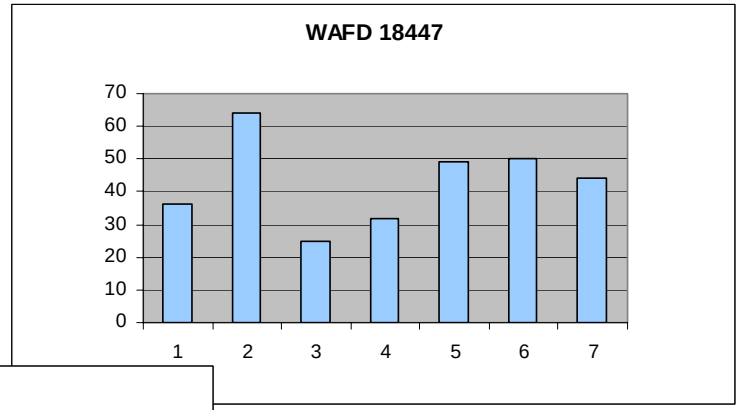


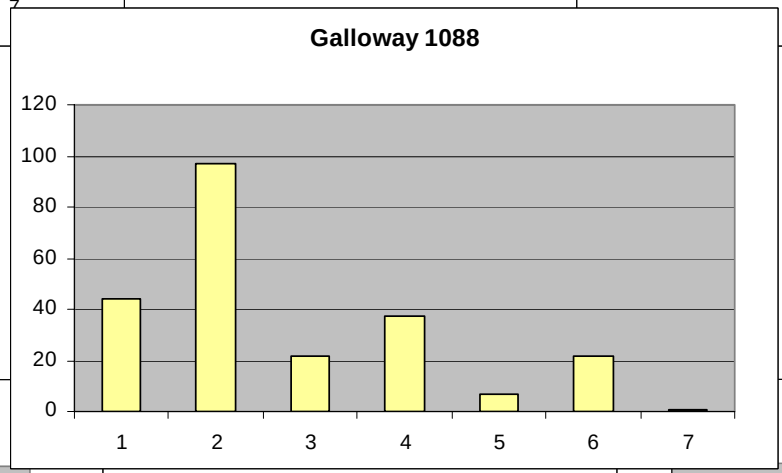
Part 4: Operational Use

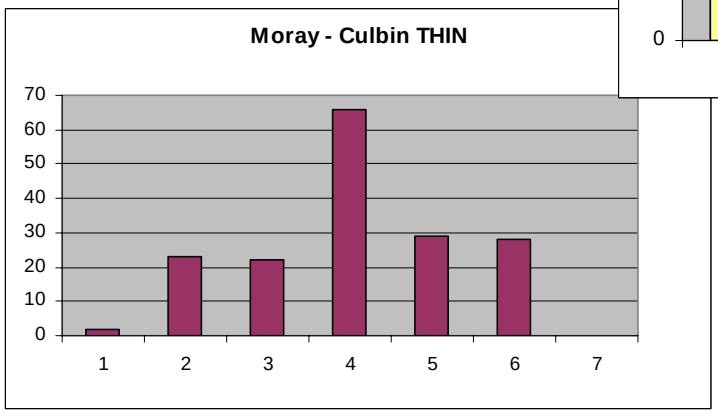
- Pre-harvest stem straightness assessment together with standard tariff measurements (60-100 trees). Allows assessment of product breakout.
- Acoustic velocities on trees prior to harvesting/logs at roadside/logs in sawmill (60-80 trees or logs). Allows assessment of probable sawn timber performance
- The earlier in the wood-chain the measurement the more flexibility in decision making but the weaker the correlation with final product performance

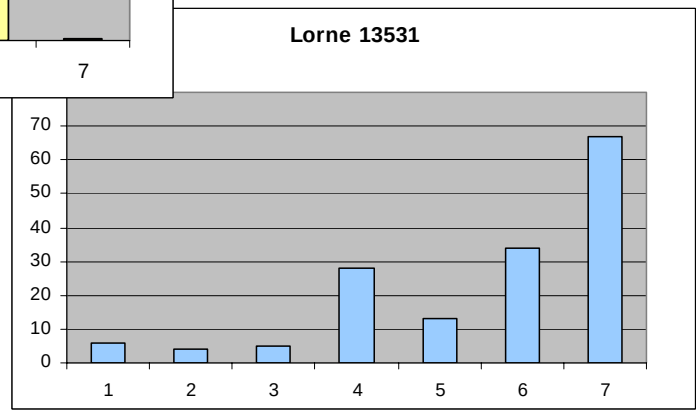
Variation in Stem Straightness











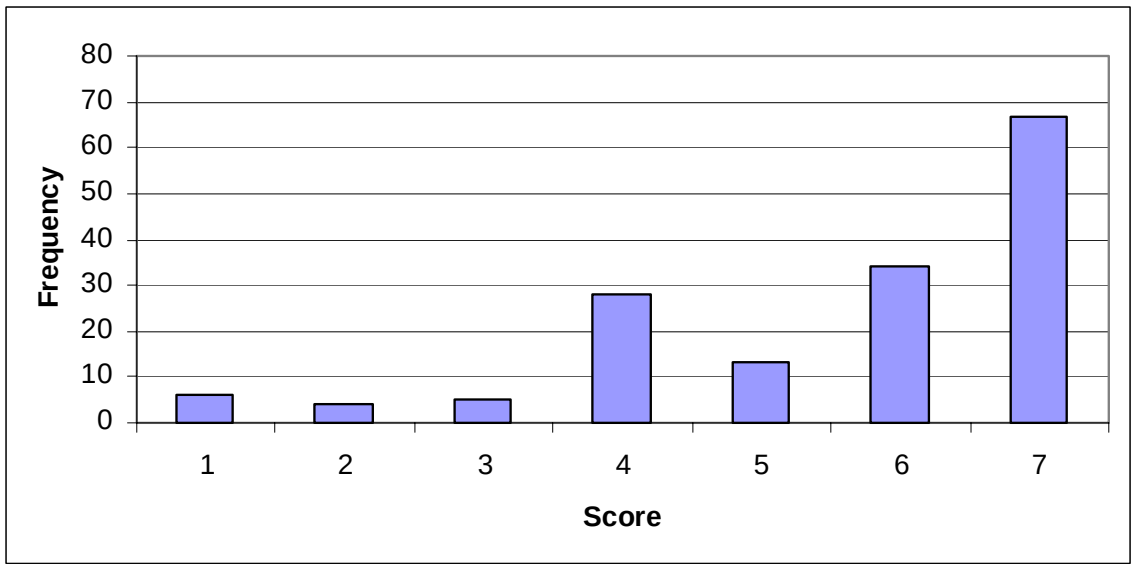
Log Breakout from Measured Stem Straightness

Log Valuation **Coupe: Ardmore 13531** **Model : West Coast 2**

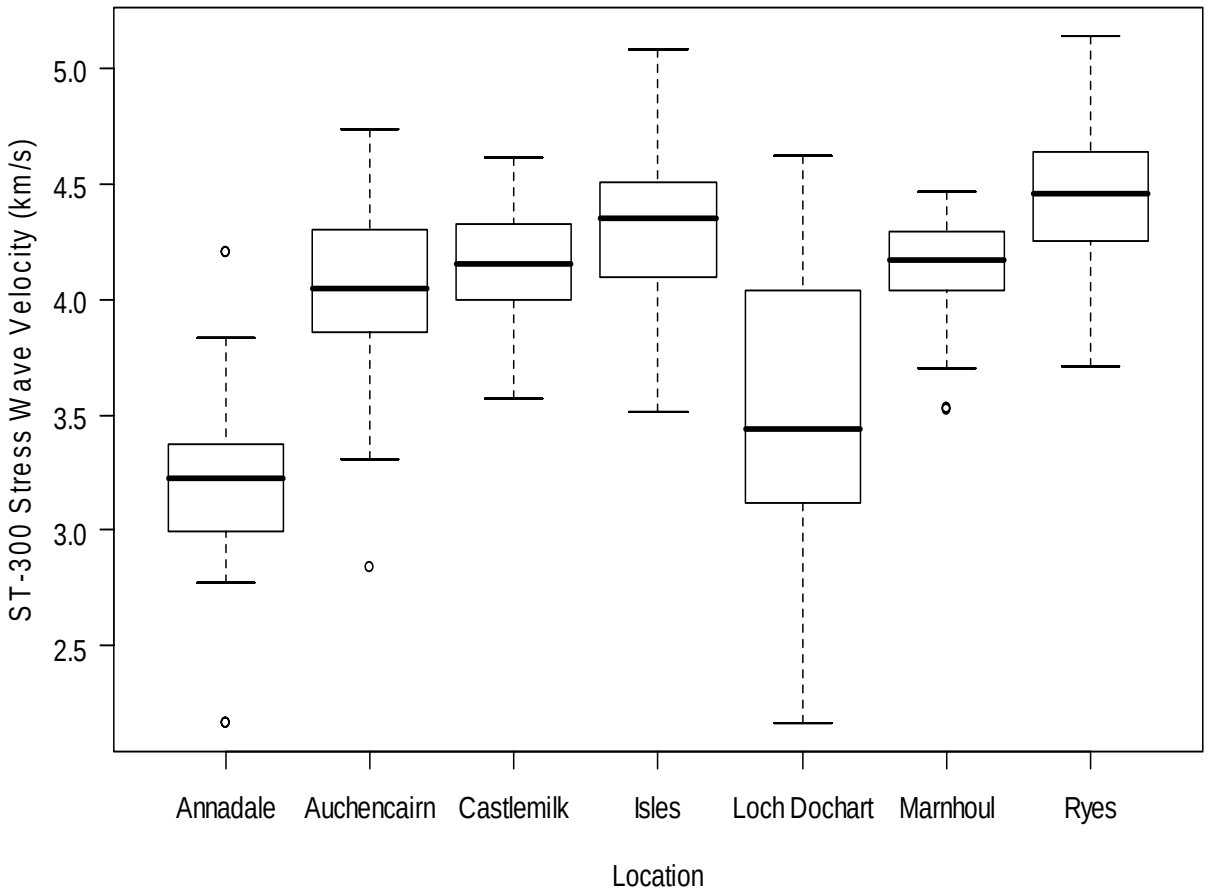
Stem score	Cumulative score	% Score	Vol/score	Potential Log lengths	Product	Vol by length	Reject 3%	Actual Vol x 3% loss	Conversion loss x 10%	Av. Acoustic score	Acoustic Grade	Building Grade
1	6	3.82	390.04	0	0		11.70	378.34	340.50			
2	4	2.55	260.03	2.5	2.5							
3	5	3.18	325.03	2.5	2.5	585.1	17.55	567.51	510.76			
4	28	17.83	1820.18	3.1 + 3.7	3.7	1820.2	54.61	1765.57	1589.02			
5	13	8.28	845.08	2.5 + 3.1 +3.7	3.1 or 2.5	1195.1	35.85	1159.28	1043.35			
6	34	21.66	2210.22	4.2 + 4.8	4.8	2210.2	66.31	2143.91	1929.52	3.31	'green'	C16 to C22
7	67	42.68	4355.43	4.8 + 5.2 + 5.4 + 6.2	5.4	4355.4	130.66	4224.76	3802.29			
Total stems	157					10166.0	304.98	9861.03	**8874.93**			

Total m3 **10,206**

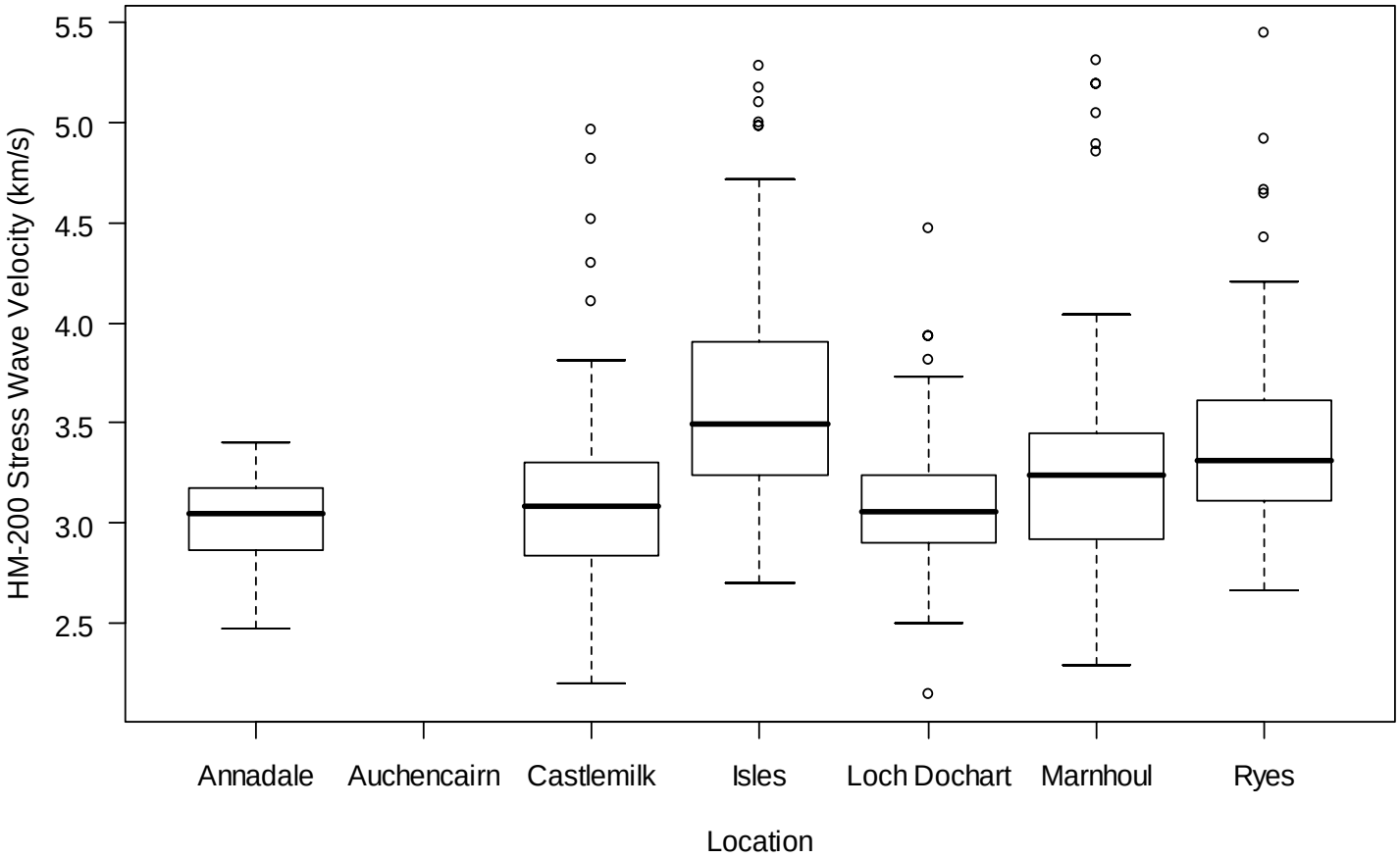
Volume Total 9214



Variation in Tree Acoustic Velocities in South Scotland Sitka Spruce

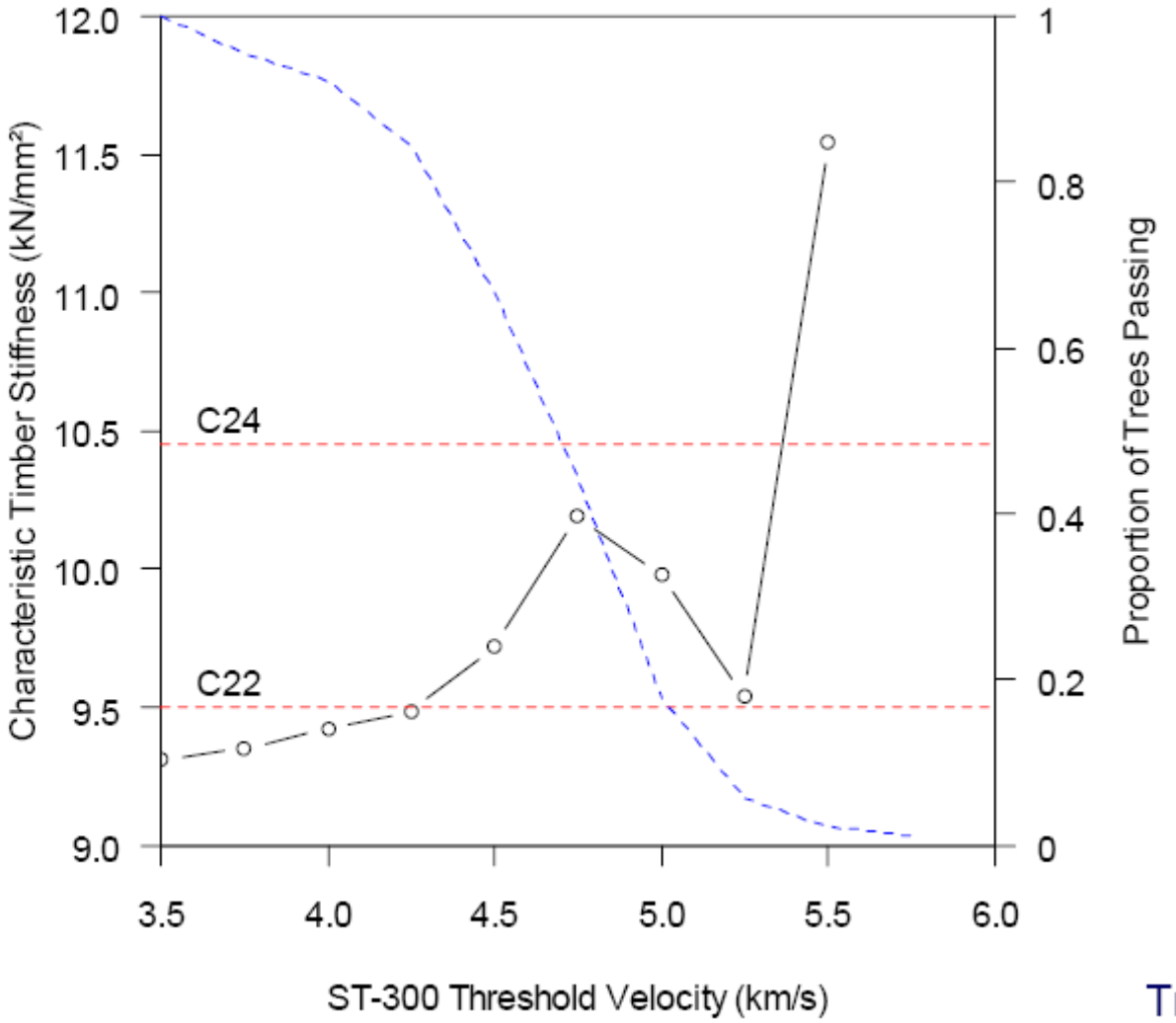


Variation in Log Acoustic Velocities in South Scotland Sitka Spruce



Segregating Trees in Scots Pine

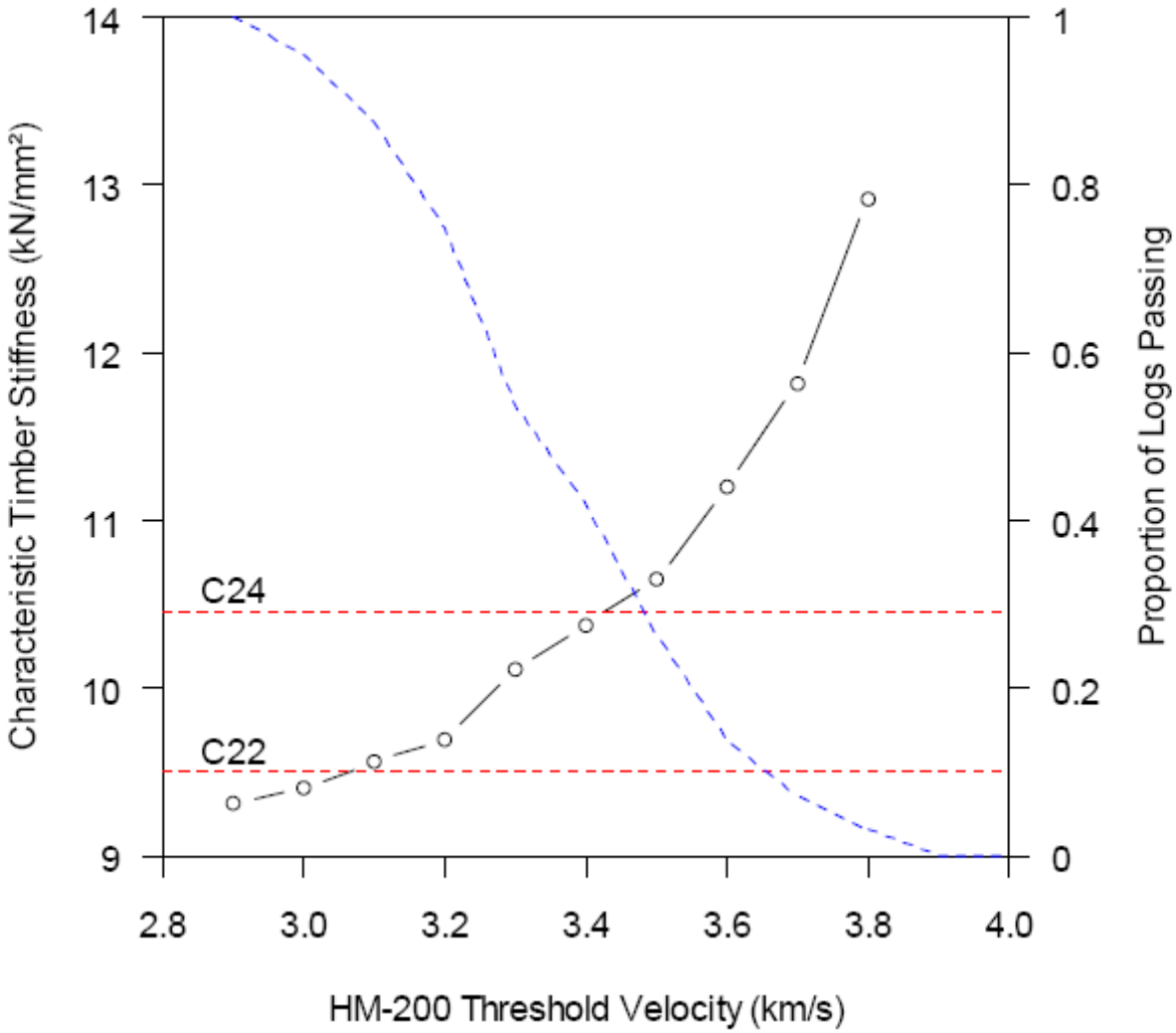
(courtesy Napier University)



Tree level

Segregating Logs in Scots Pine

(courtesy Napier University)



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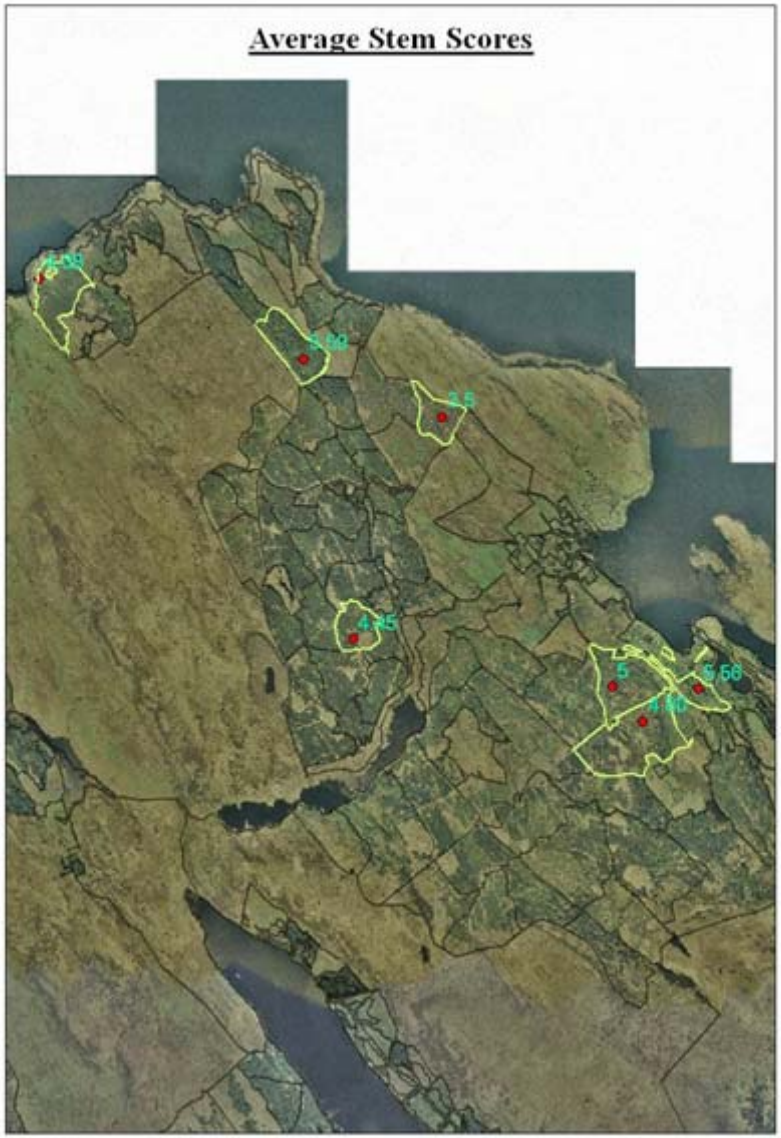

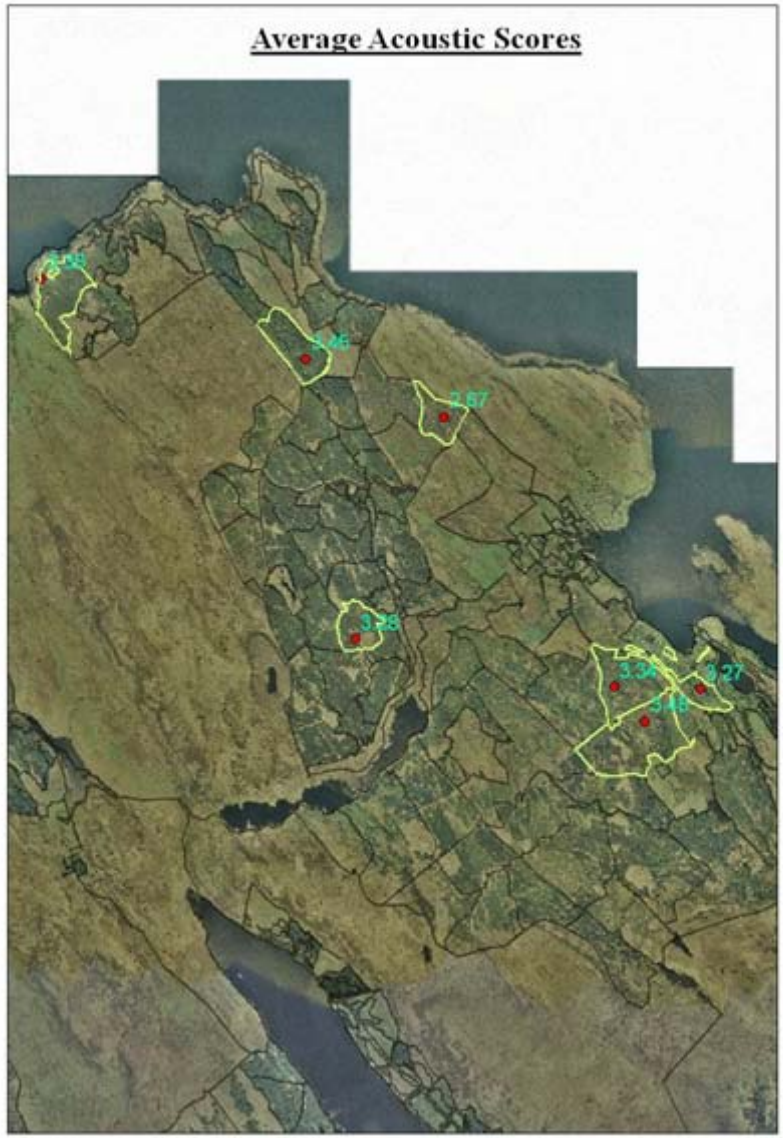

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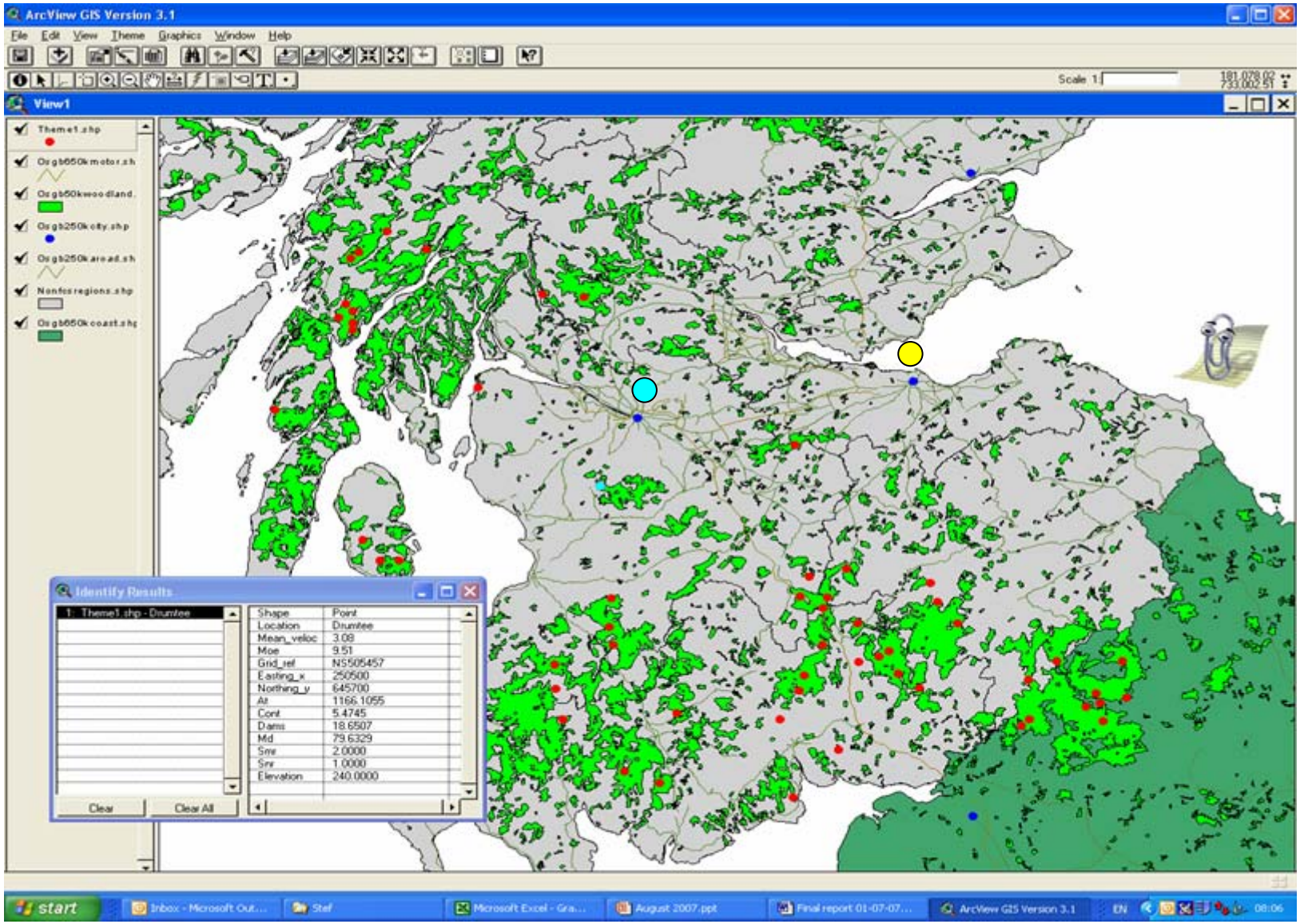

Timber Quality Assessment

Trial sites:

1.	Moray FD – Culbin	Stem Straightness and Acoustics
2.	Lorne FD – Ardmore	Stem Straightness and Acoustics
3.	Lochaber FD – Corrour	Stem Straightness and Acoustics
4.	Aberfoyle FD	Stem Straightness and Acoustics
5.	Tay FD	Stem Straightness and Acoustics
6.	Wales 2-3 harvesting sites	Stem Straightness and Acoustics

- Measure stem straightness before felling. 150 – 300 trees
- Measure acoustics on roadside logs c350 –500logs
- GIS mapping of results and input from Operations and Planning within FE.
- Compare harvesting data (stem files .stm) with straightness breakout model.

Costs:

- 10hours for 10,000m^3 = 2 days@ £257/day = £514 or £0.05/m3

Savings:

- Can reduce costs by up to 7%

Summary

- Large variation in stem form within and between stands
- Large acoustic variation within stands and between stands
- Good relationship between stem form and height of lowest dead branch and green log percentage outturn
- Good relationship between tree and log acoustic values and the indicating properties used for grading
- Now have the ability to accurately measure stem shape and form in stands
- Now have tools for measuring stiffness in standing trees and logs

Future

- Build systems that utilise stem straightness and acoustics to more accurately predict product outturn and product performance.
- Use tools to determine optimum log cross-cutting, log allocation, tree/log selection, logistic solutions, and optimized wood-chain operations

References

- Macdonald, E. Mochan, S.J. and Connolly, T. 2001. *Protocol for Stem Straightness Assessment in Sitka Spruce.* Forestry Commission Information Note 39, Forestry Commission Edinburgh.
- Macdonald, E. Mochan, S.J. and Connolly, T. 2009. Development of a stem straightness scoring system for Sitka spruce (*Picea sitchensis* (Bong.) Carr.). Forestry, In Press.
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- http://www.forestresearch.gov.uk

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