Forest Quality
MORE VALUABLE TREES

Tools and models for assessing wood quality in Australian radiata pine

Validation and development of eCambium software tool

Geoff Downes
Forest Quality Pty. Ltd.

Dave Drew
Forest Forecasting

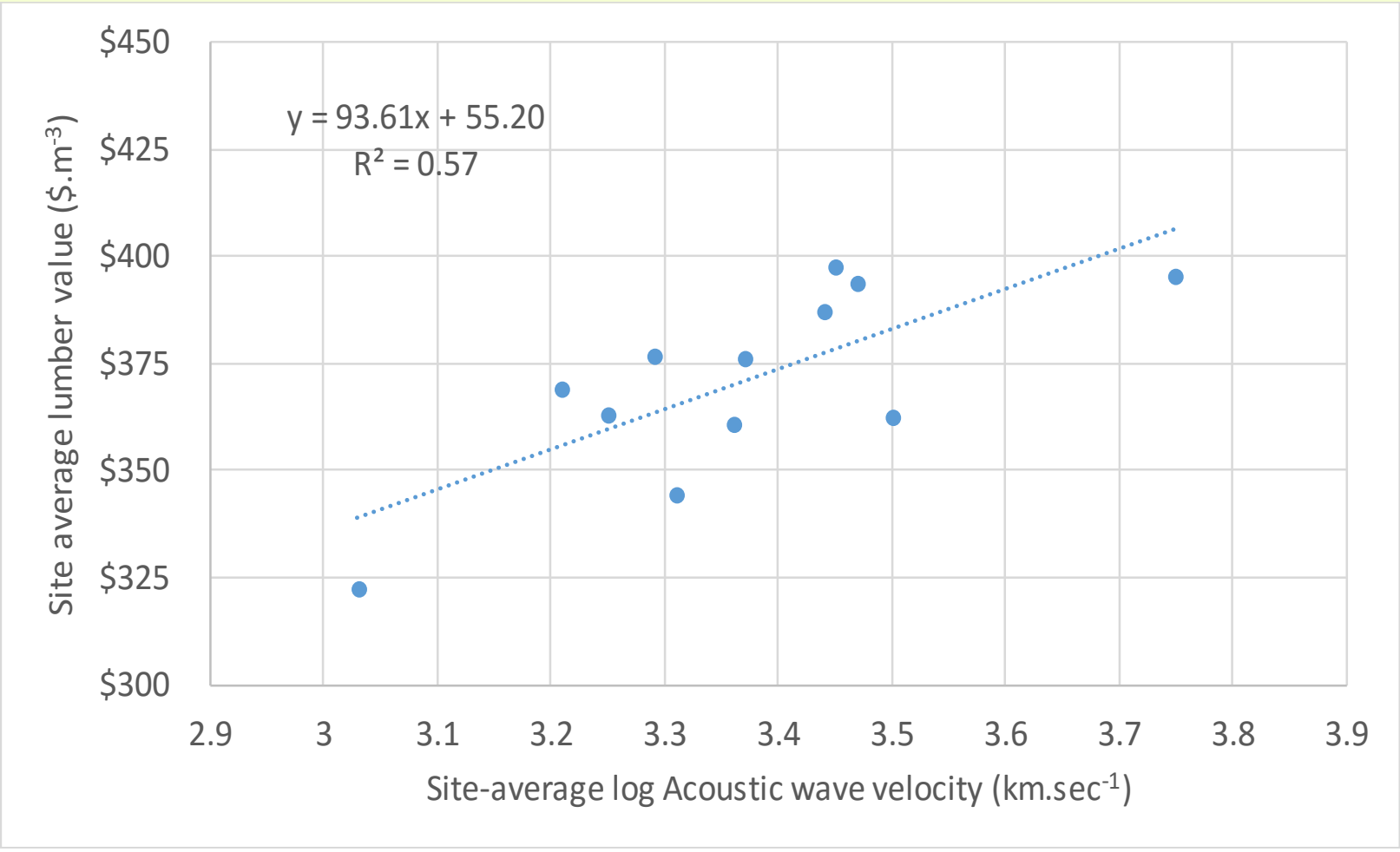
Forest & Wood Products Australia

Forest Quality Pty Ltd

- Applied R&D based in southern Tasmania
  - 20 years working for CSIRO in Forestry and Forest Products
    - CRC Hardwood Fibre and Paper Science (1992 –1999)
    - SilviScan Services (2000-2003)
    - Ensis Joint Venture with Scion (NZ) (2003-2008)
    - CRC Forestry Ltd (2005 – 2012)
- Spin-off company from the CRC Forestry Ltd. (Est. July 2012)
- Focus on wood property assessment and modelling
  1. NIR assessment of Eucalypt pulp properties
  2. In-field assessment of wood properties and training
     - Increment coring | IML Resistograph |Portable NIR
  3. Process-based modelling of wood properties
     - FWPA funded **eCambium** projects in radiata pine (2010 -2016)

Forest Quality
MORE VALUABLE TREES

Wealth generation

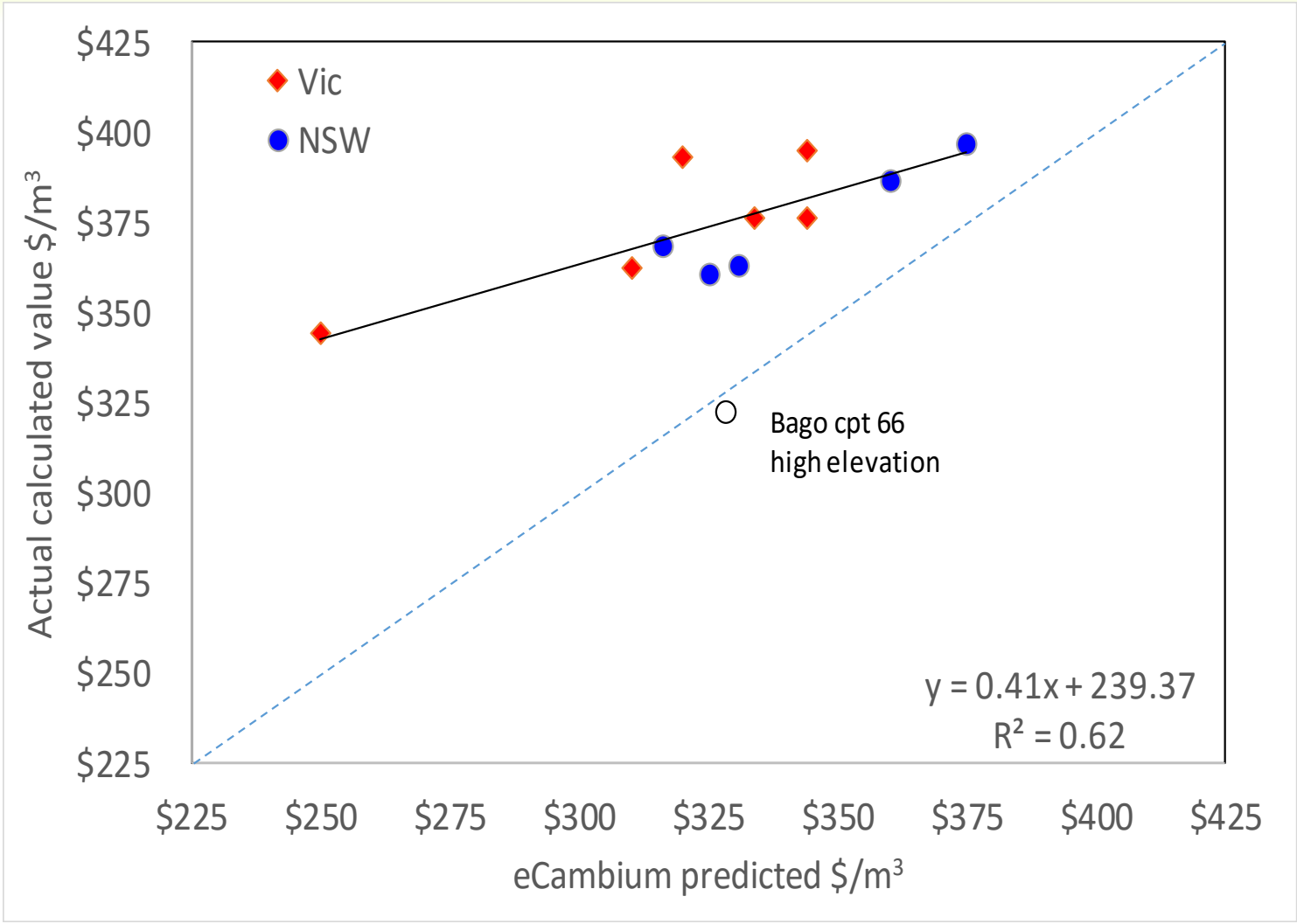


Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

eCambium's prediction of site value

- eCambium predictions made 4 months before logs were harvested

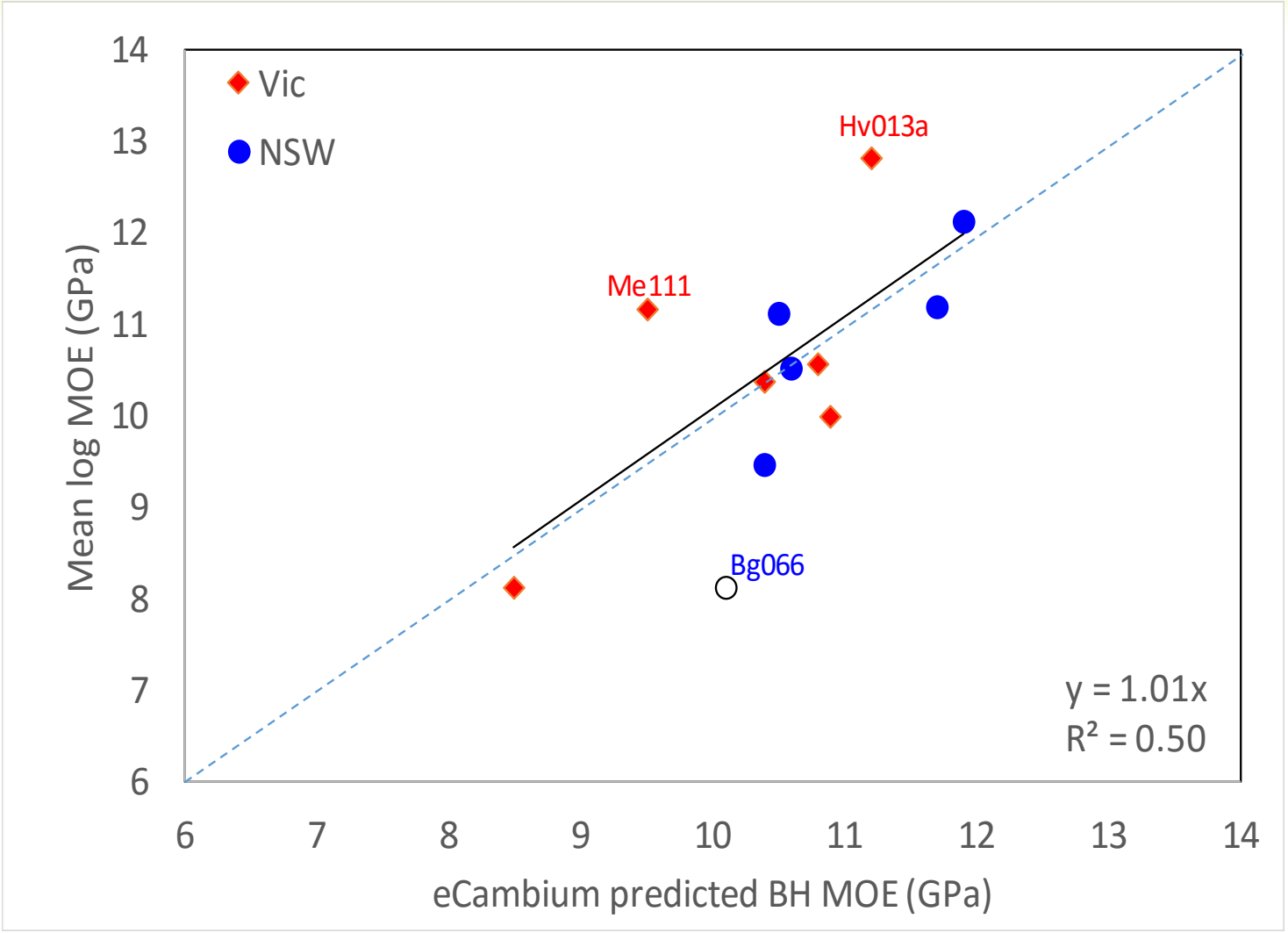


Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

eCambium's prediction of log MOE

- eCambium predictions made 4 months before logs were harvested

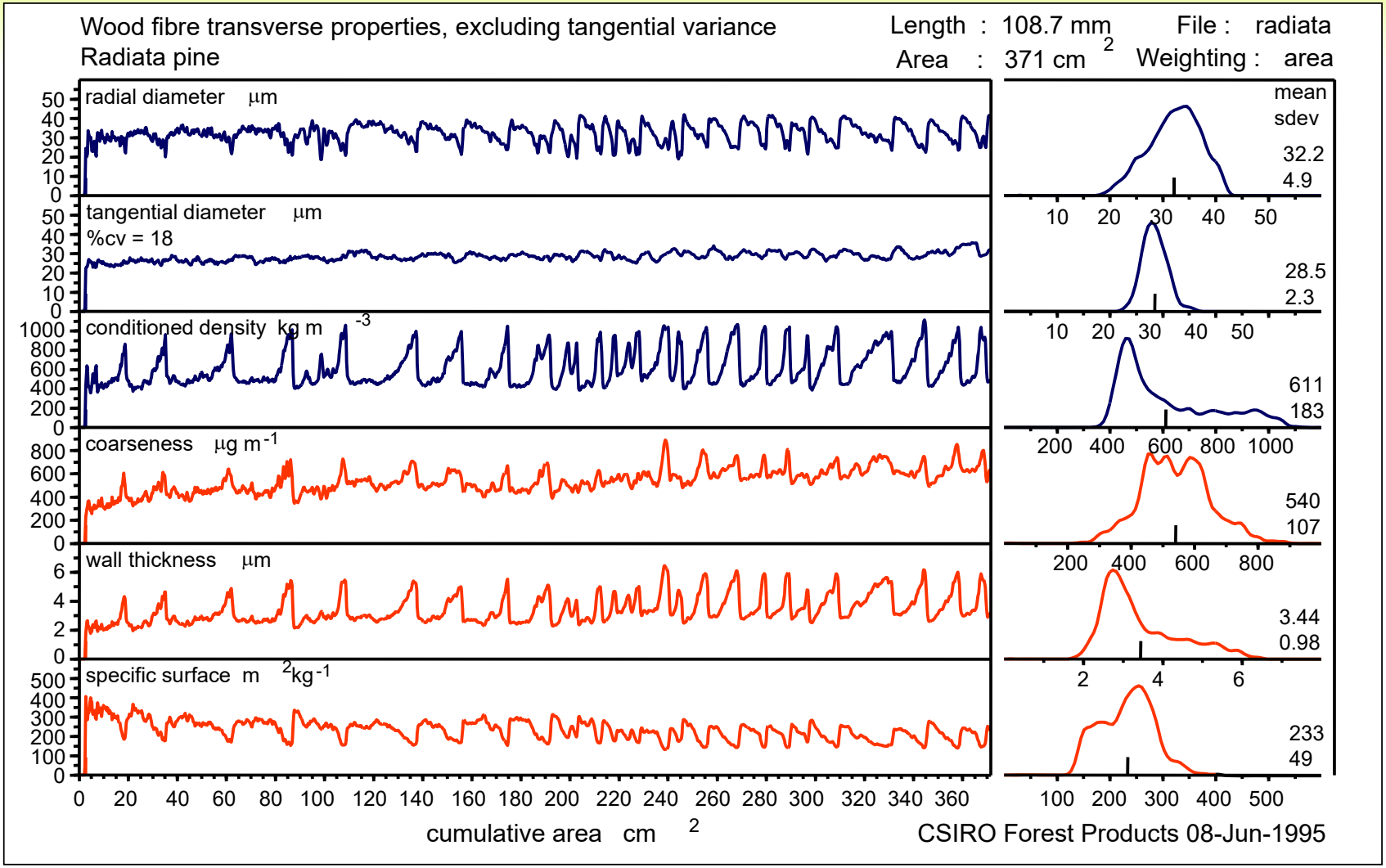


Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Typical SS-1 Analysis Report (circa 1995)

Cost:
~$200 per radial core



Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

SilviScan mapping of wood stiffness variation within trees

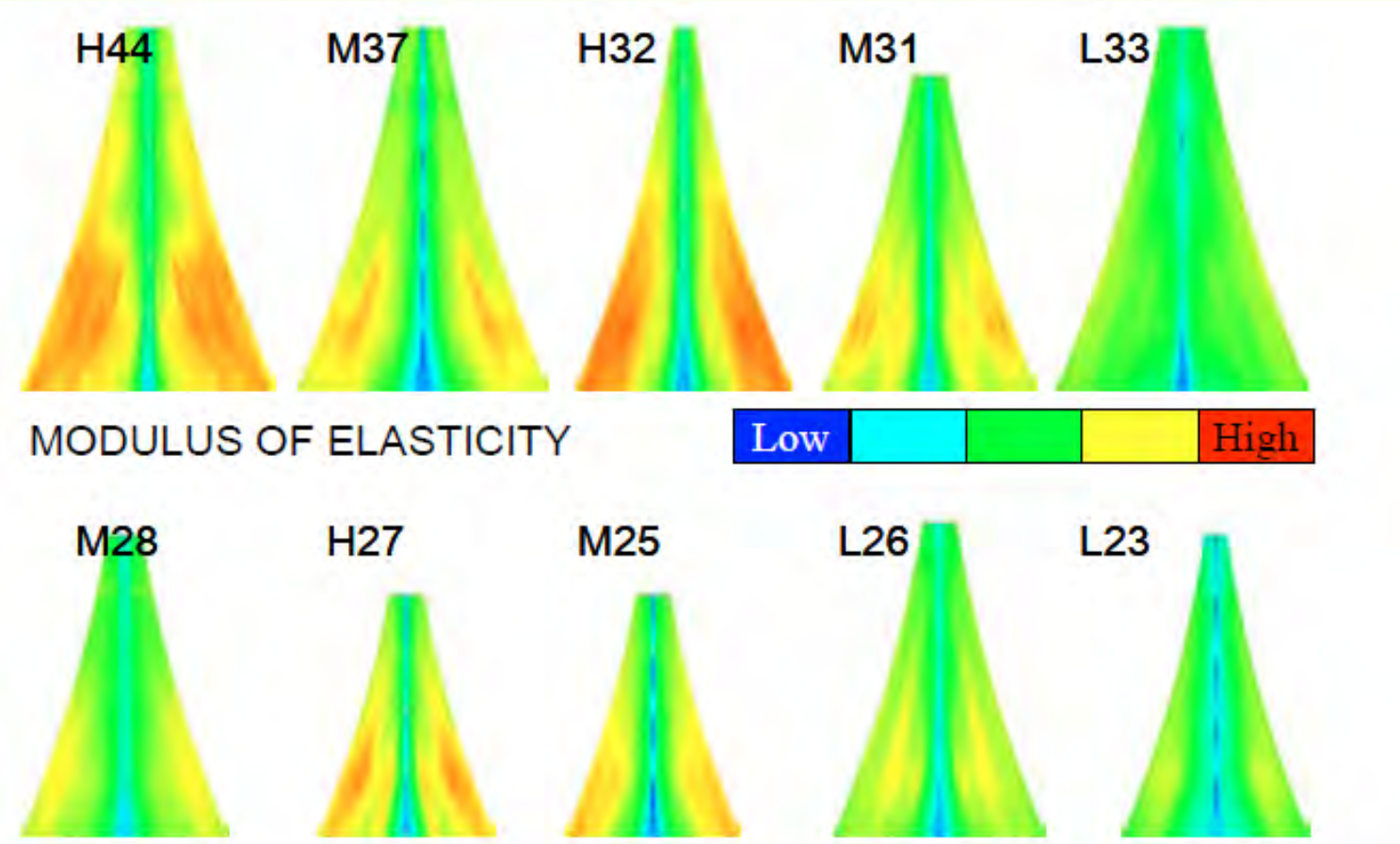


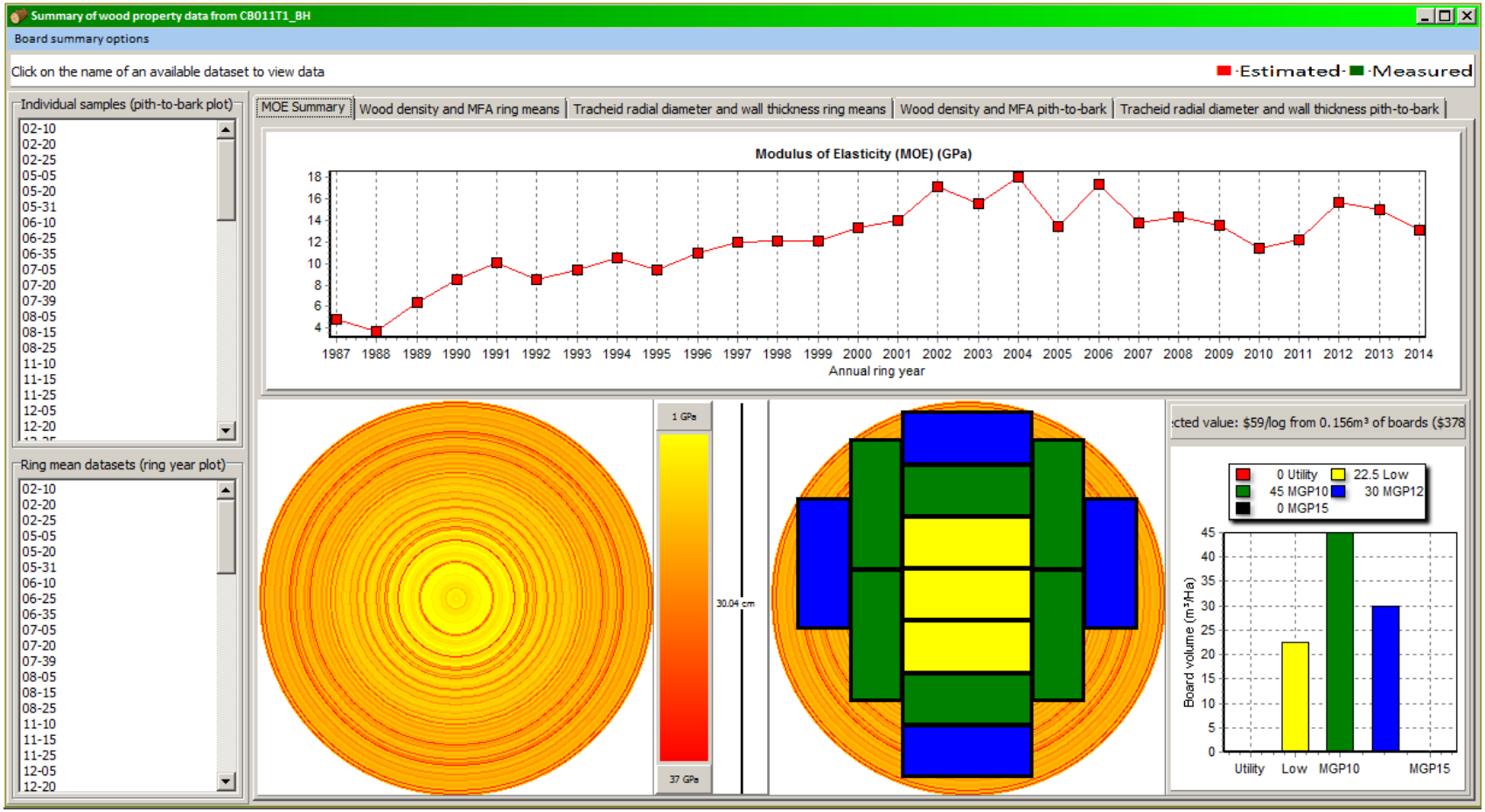
Figure 20: Site average whole-tree maps for SilviScan estimated Modulus of Elasticity

Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Overview of eCambium (Version 2.1)

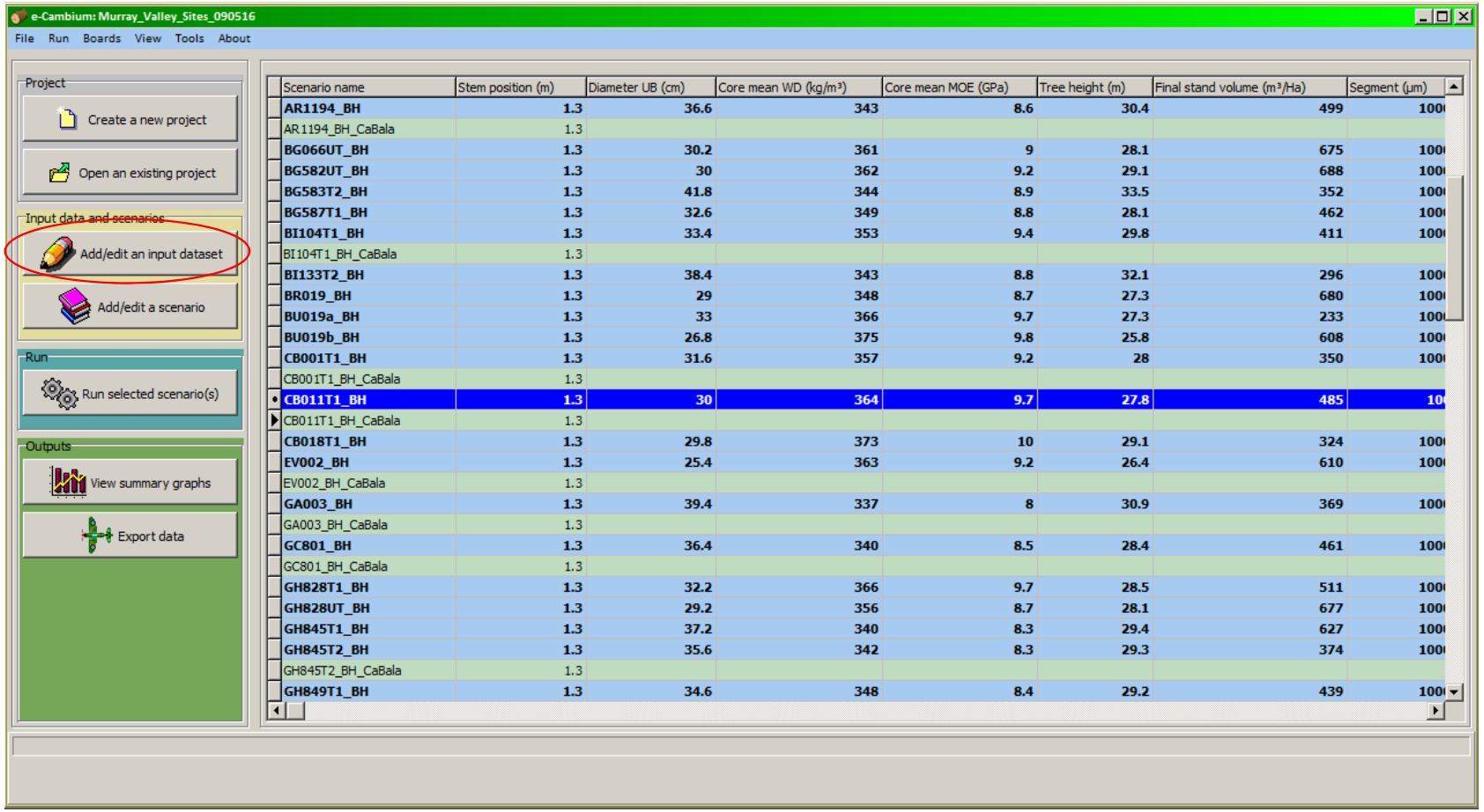
- eCambium predictions of wood variation link effects of growth on board volume and quality



Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

eCambium's main user interface

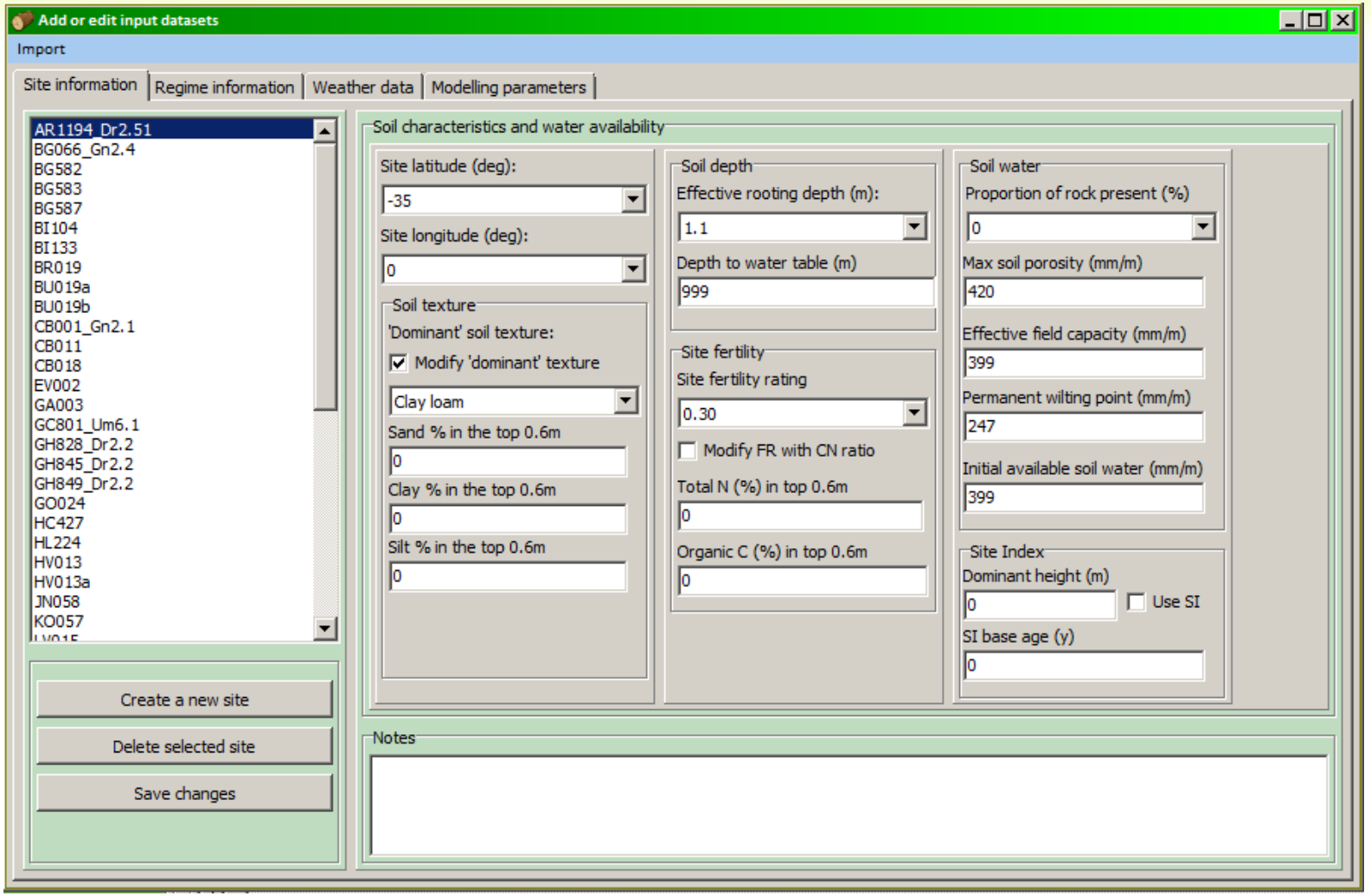


Scenario name	Stem position (m)	Diameter UB (cm)	Core mean WD (kg/m³)	Core mean MOE (GPa)	Tree height (m)	Final stand volume (m³/Ha)	Segment (µm)
AR1194_BH	**1.3**	**36.6**	**343**	**8.6**	**30.4**	**499**	**100**
AR1194_BH_CaBala	1.3						
BG066UT_BH	**1.3**	**30.2**	**361**	**9**	**28.1**	**675**	**100**
BG582UT_BH	**1.3**	**30**	**362**	**9.2**	**29.1**	**688**	**100**
BG583T2_BH	**1.3**	**41.8**	**344**	**8.9**	**33.5**	**352**	**100**
BG587T1_BH	**1.3**	**32.6**	**349**	**8.8**	**28.1**	**462**	**100**
BI104T1_BH	**1.3**	**33.4**	**353**	**9.4**	**29.8**	**411**	**100**
BI104T1_BH_CaBala	1.3						
BI133T2_BH	**1.3**	**38.4**	**343**	**8.8**	**32.1**	**296**	**100**
BR019_BH	**1.3**	**29**	**348**	**8.7**	**27.3**	**680**	**100**
BU019a_BH	**1.3**	**33**	**366**	**9.7**	**27.3**	**233**	**100**
BU019b_BH	**1.3**	**26.8**	**375**	**9.8**	**25.8**	**608**	**100**
CB001T1_BH	**1.3**	**31.6**	**357**	**9.2**	**28**	**350**	**100**
CB001T1_BH_CaBala	1.3						
CB011T1_BH	**1.3**	**30**	**364**	**9.7**	**27.8**	**485**	**10**
CB011T1_BH_CaBala	1.3						
CB018T1_BH	**1.3**	**29.8**	**373**	**10**	**29.1**	**324**	**100**
EV002_BH	**1.3**	**25.4**	**363**	**9.2**	**26.4**	**610**	**100**
EV002_BH_CaBala	1.3						
GA003_BH	**1.3**	**39.4**	**337**	**8**	**30.9**	**369**	**100**
GA003_BH_CaBala	1.3						
GC801_BH	**1.3**	**36.4**	**340**	**8.5**	**28.4**	**461**	**100**
GC801_BH_CaBala	1.3						
GH828T1_BH	**1.3**	**32.2**	**366**	**9.7**	**28.5**	**511**	**100**
GH828UT_BH	**1.3**	**29.2**	**356**	**8.7**	**28.1**	**677**	**100**
GH845T1_BH	**1.3**	**37.2**	**340**	**8.3**	**29.4**	**627**	**100**
GH845T2_BH	**1.3**	**35.6**	**342**	**8.3**	**29.3**	**374**	**100**
GH845T2_BH_CaBala	1.3						
GH849T1_BH	**1.3**	**34.6**	**348**	**8.4**	**29.2**	**439**	**100**

Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

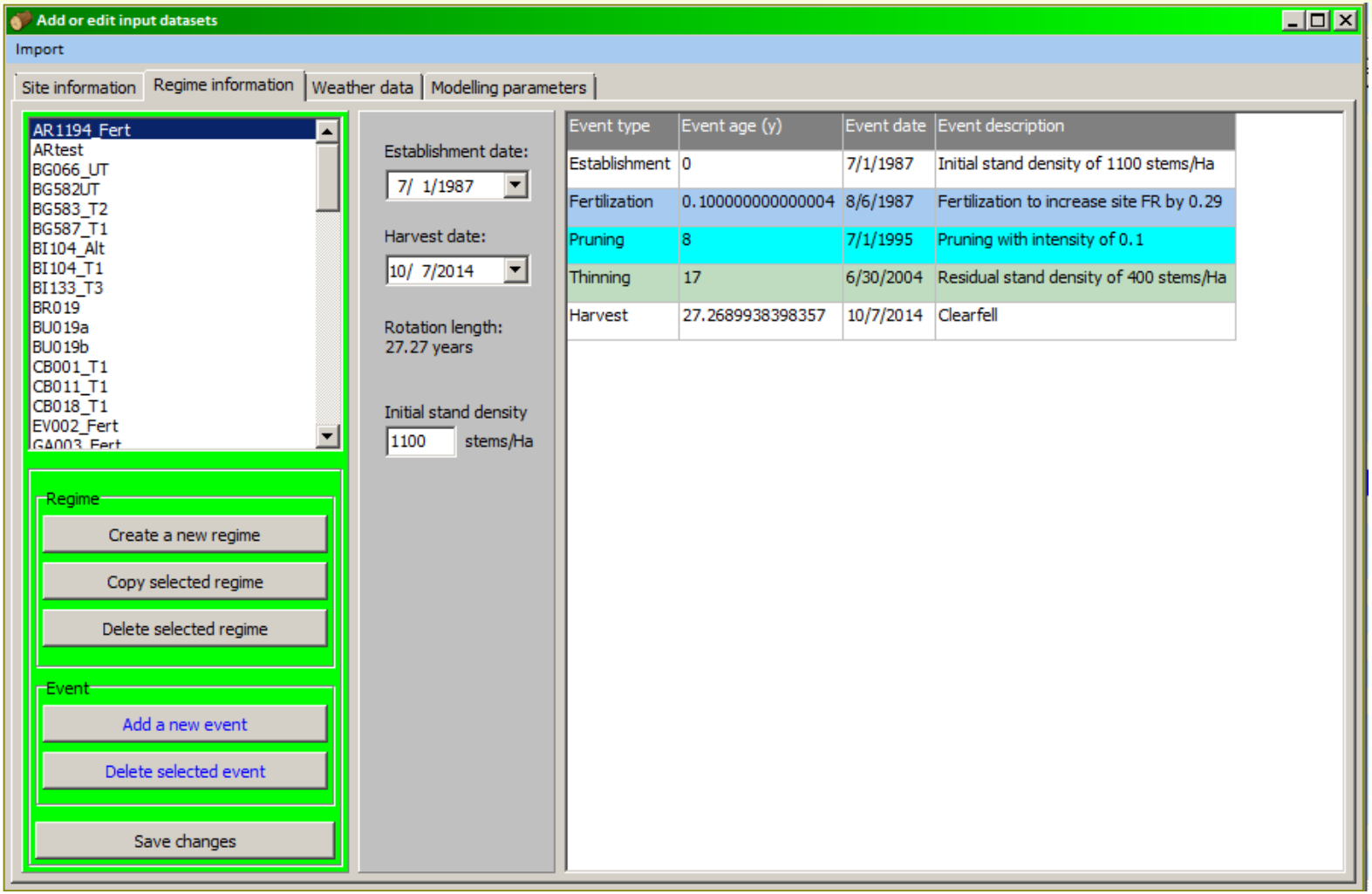
Defining site



Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

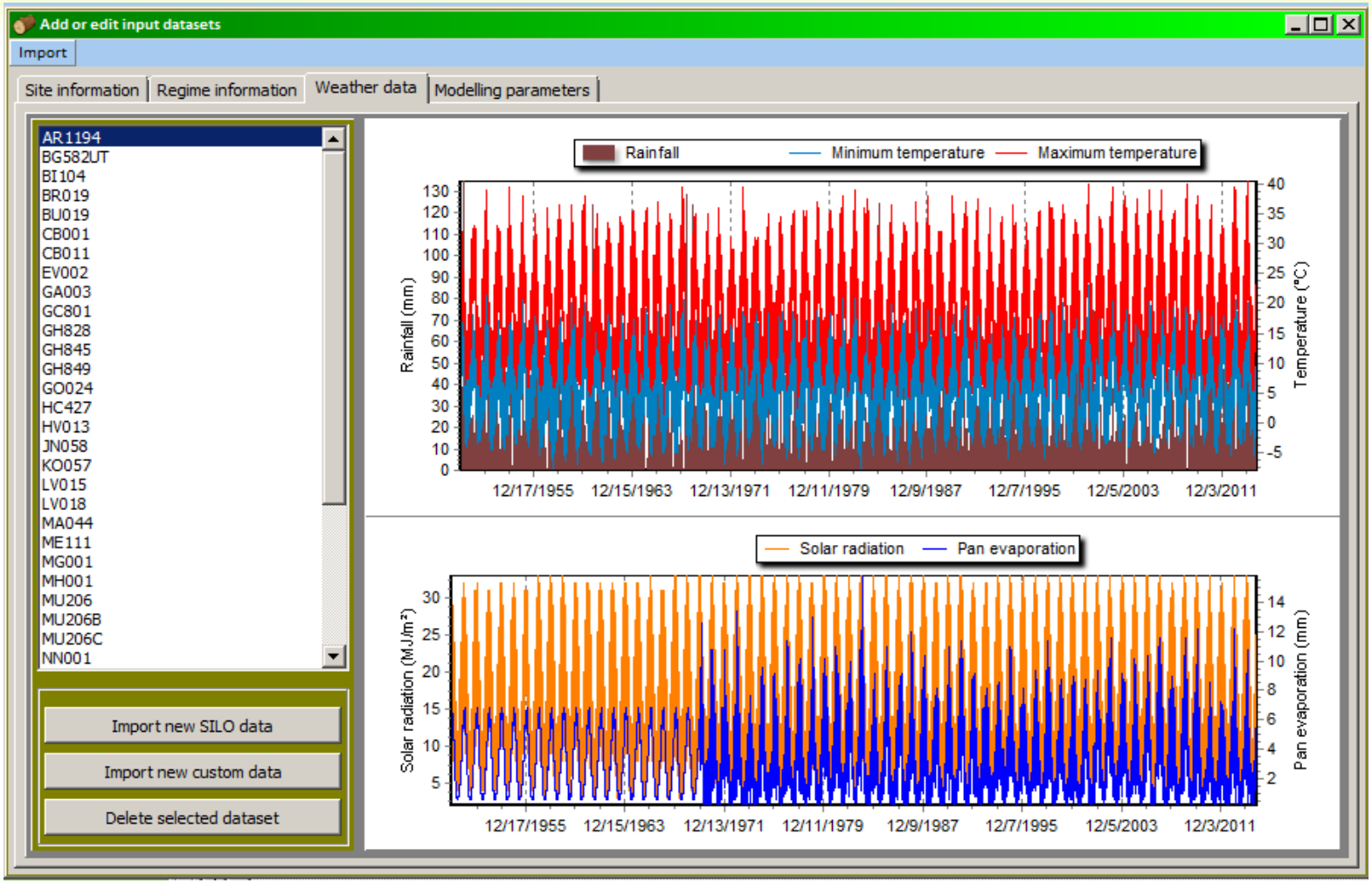
Defining regime



Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

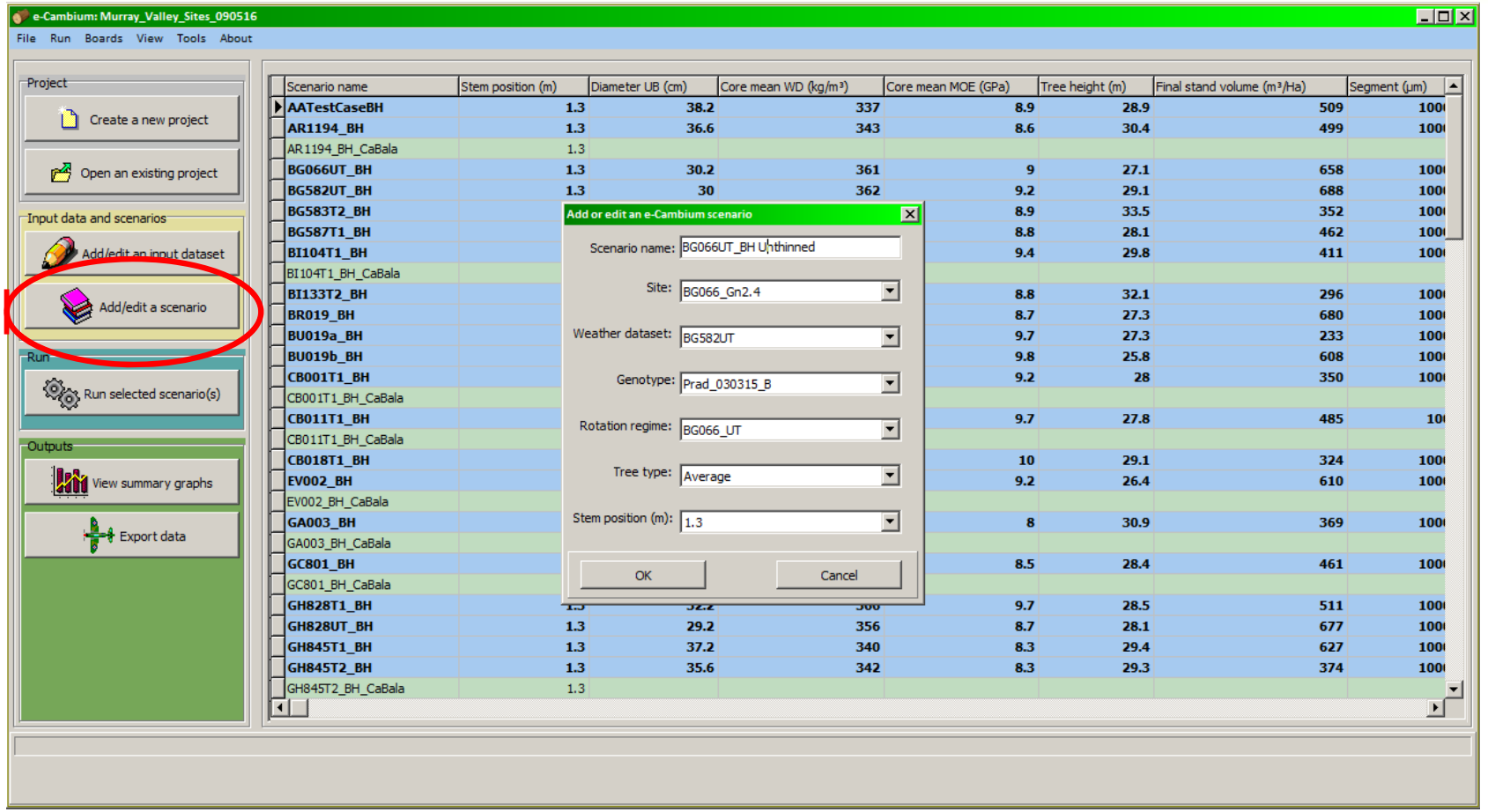
Defining weather



Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Building a “scenario”

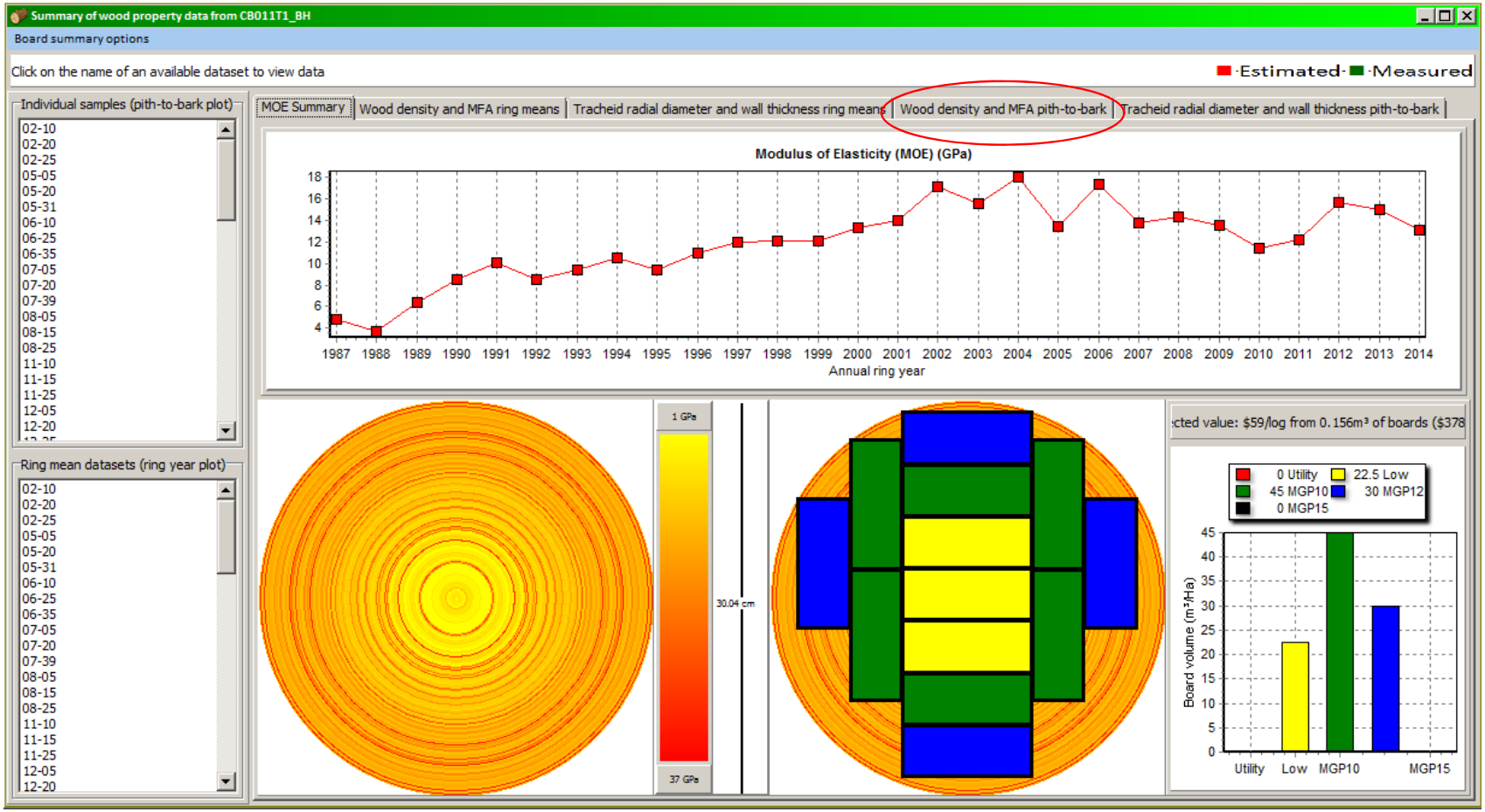


Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Overview of eCambium (Version 2.1)

- eCambium predictions of wood variation link effects of growth on board volume and quality

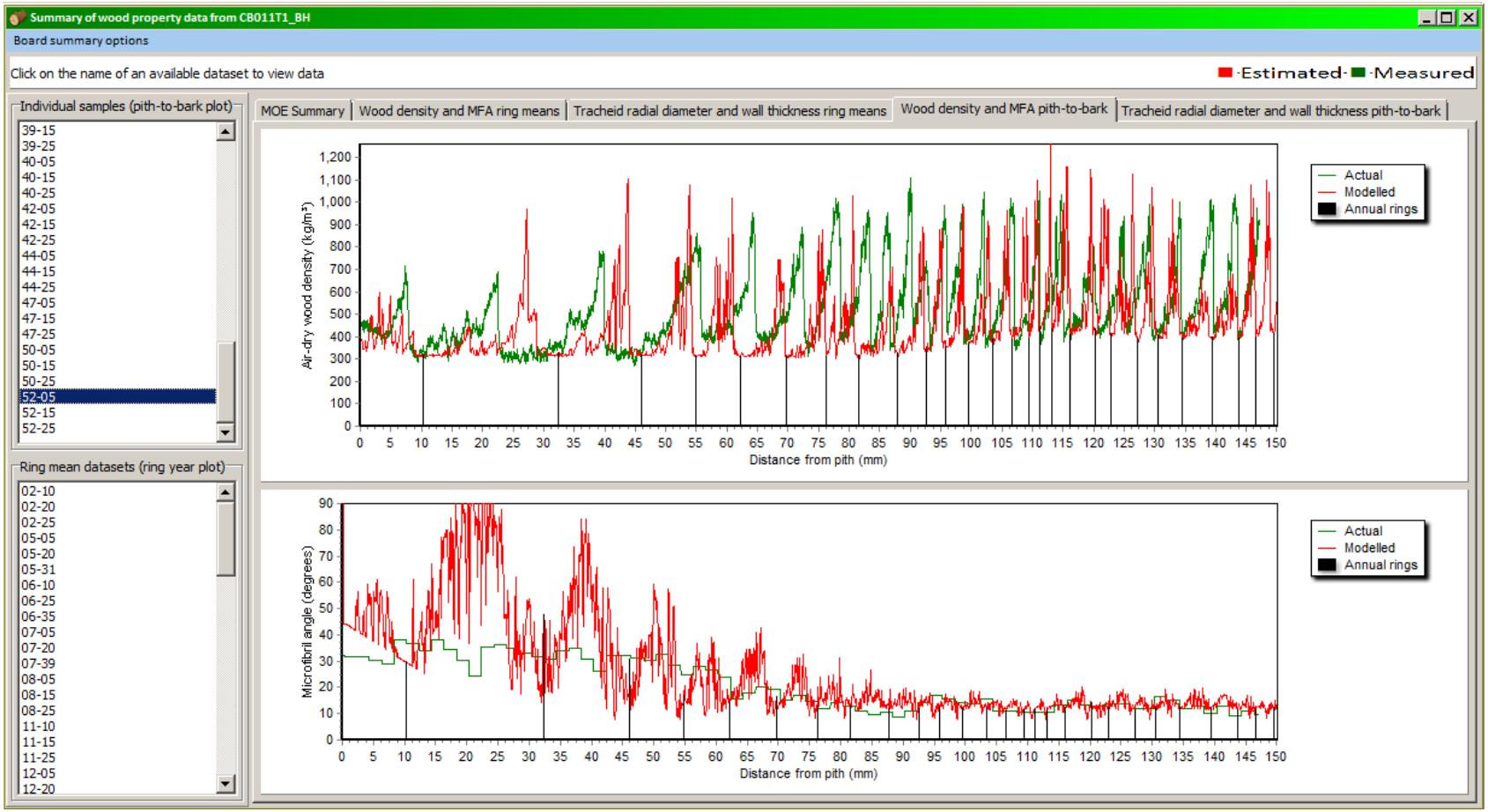


Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Drilling down into the lower level values

- Daily predictions of
- Wood density
- MFA
- Fibre diameter
- Fibre wall thickness



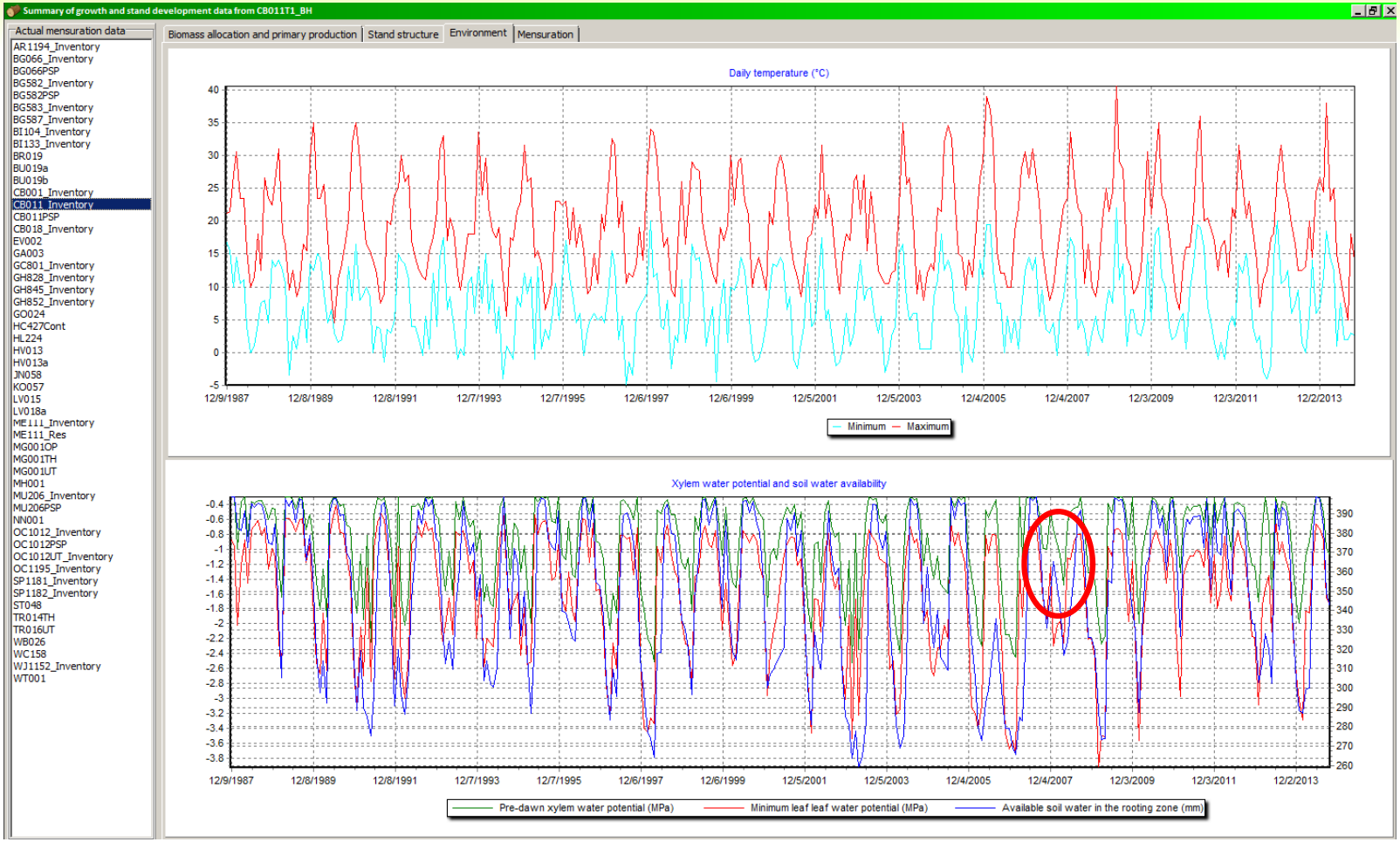
Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Tree growth predictions

Predictions of

- Height
- DBH
- Stand Volume
- Soil water availability
- Predawn water potential



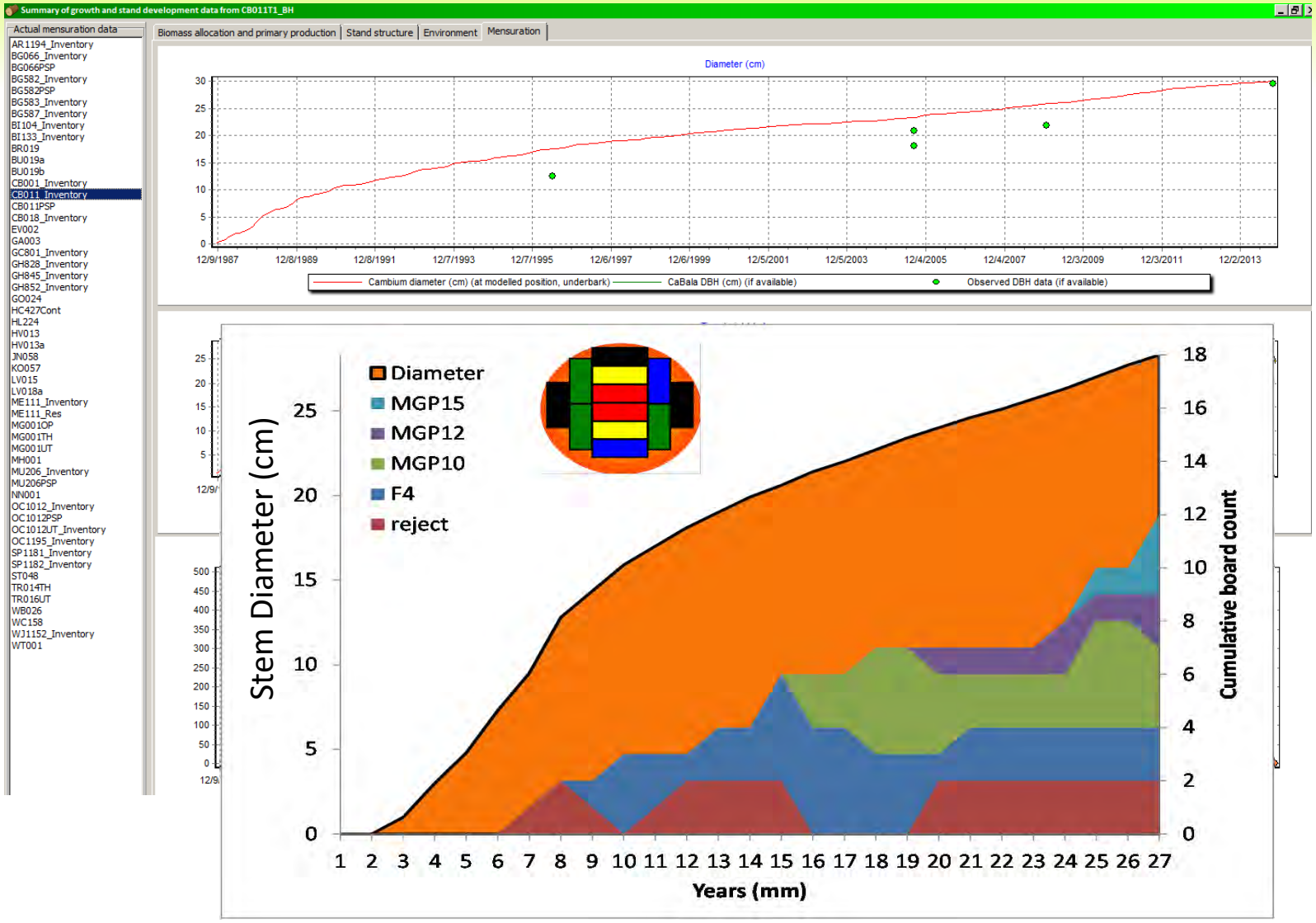
Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Tree growth predictions

Predictions of

- Height
- DBH
- Stand Volume
- Soil water availability
- Predawn water potential



Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Murray Valley Basin Validation

Project Objectives

- Regional assessment of wood property variation from *P. radiata* sites in the Murray Valley Basin
  - close to harvest
  - represent wide range of resource variability

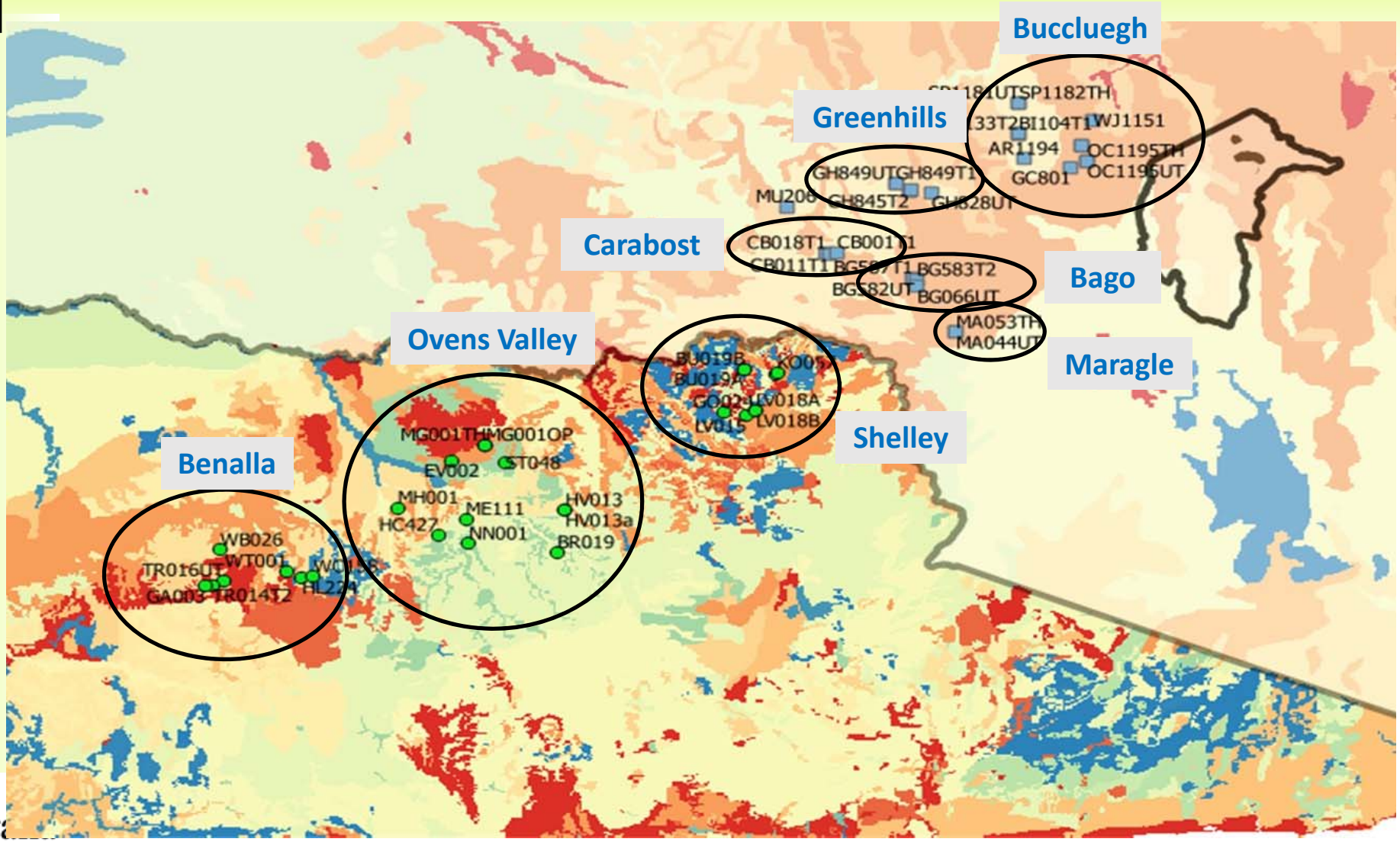
- Obtain a representative data set describing site average and variance data of tree and wood properties as a basis for evaluating the performance of the eCambium modelling tool

- Produce a "commercially-ready" version of eCambium

Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Site Selection



Forest & Wood Products Austra

Forest Quality
MORE VALUABLE TREES

Stage 1: NDE Resource Evaluation

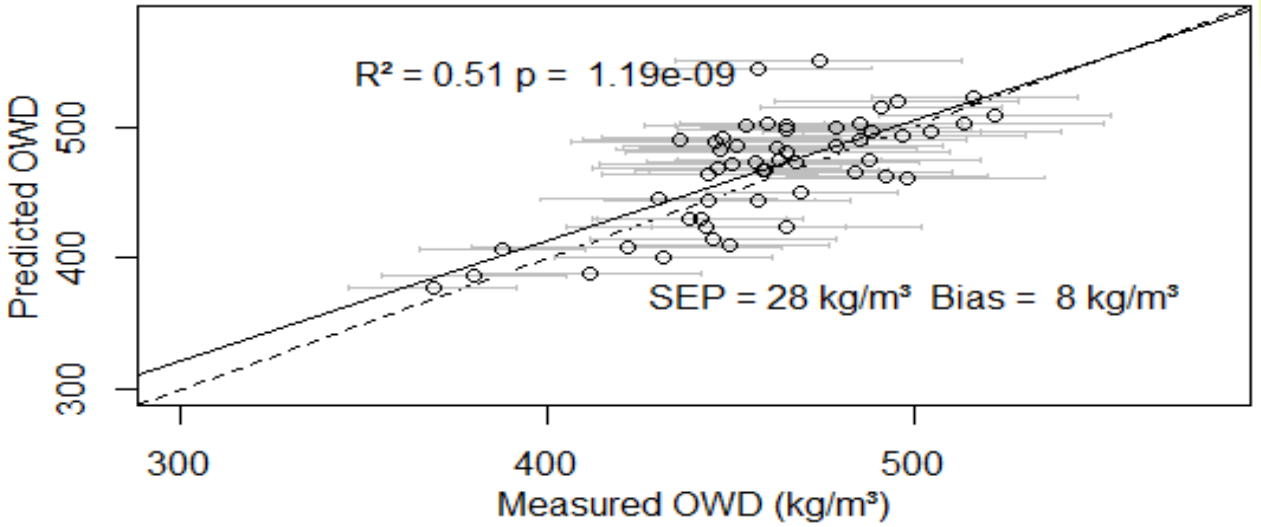
- 53 sites
- 30 trees per site
  - DBH
  - Outerwood density cores
  - Standing tree acoustic velocity (ST300)
- 6 trees per site
  - Tree height
  - Branch diameter
  - Bark thickness

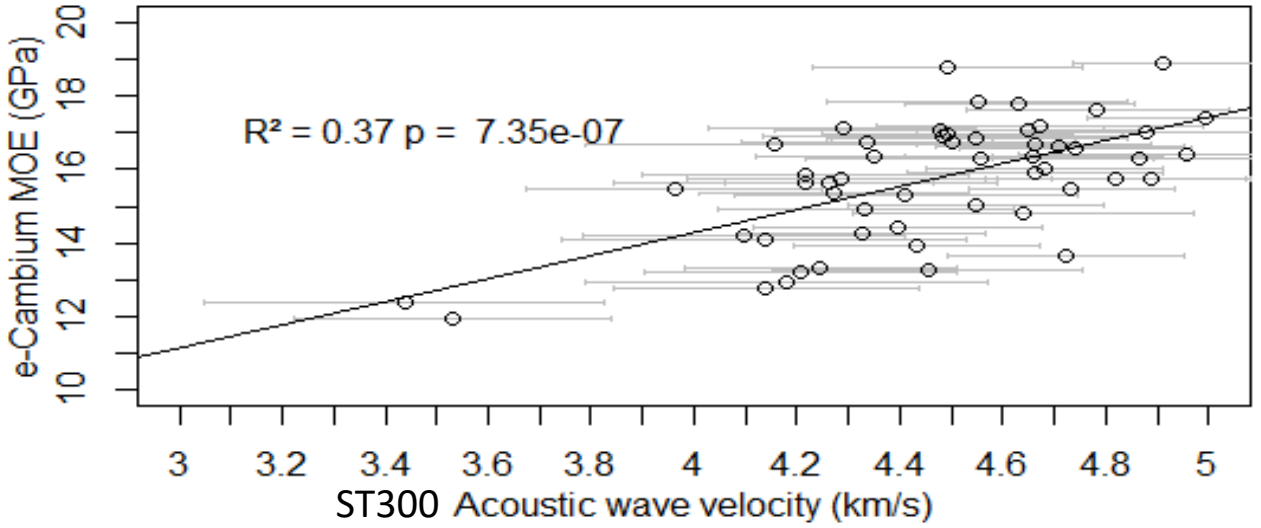
Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

eCambium prediction of outerwood density

50% of the variation in site mean OWD was predicted by eCambium





Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Fitted Empirical models of outerwood density

OWD = 396.6–1.93(Branch Diameter) + 0.174(Spring Rainfall) + 2.43(Age)

- *38% variance explained*

UT_OWD = 392–2.36(Branch Diameter) + 0.63(Autumn Rainfall) + 4.64(Max. Autumn T)+2.45(Age)

- 55% variance explained

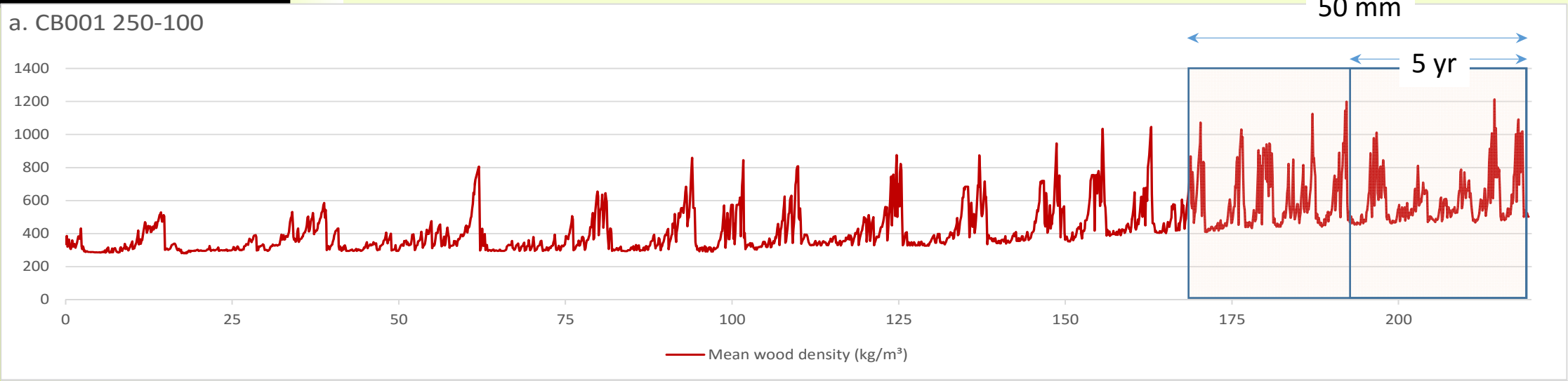
T1_OWD = 1187–2.26(Branch Diameter) – 0.476(DBHOB) – 0.066(Annual Rainfall) – 21.55(Ave Temp) – 0.07(Annual Radiation) + 10.1(Age)

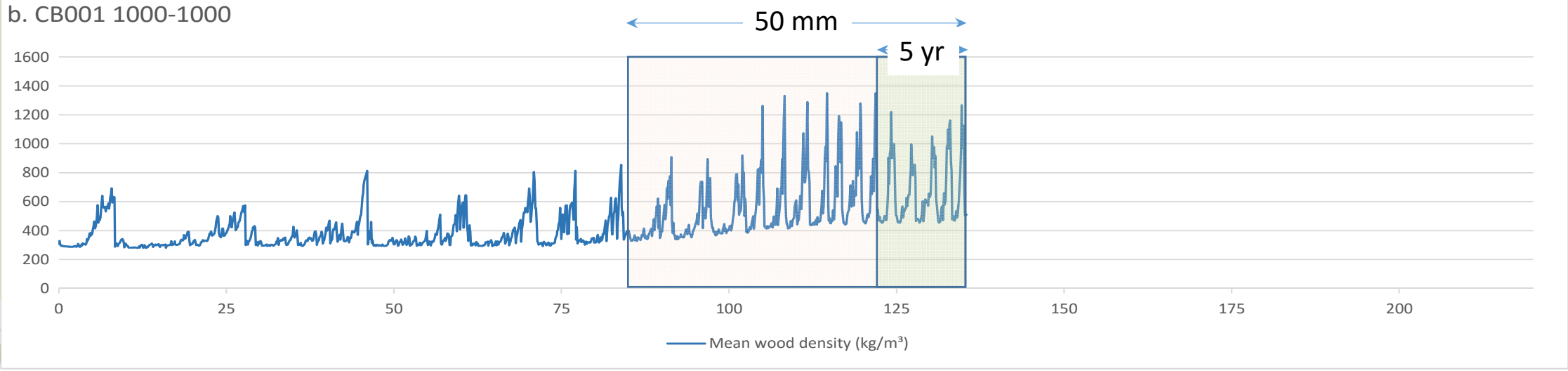
- 71% variance explained

Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Problem of 50mm outerwood cores

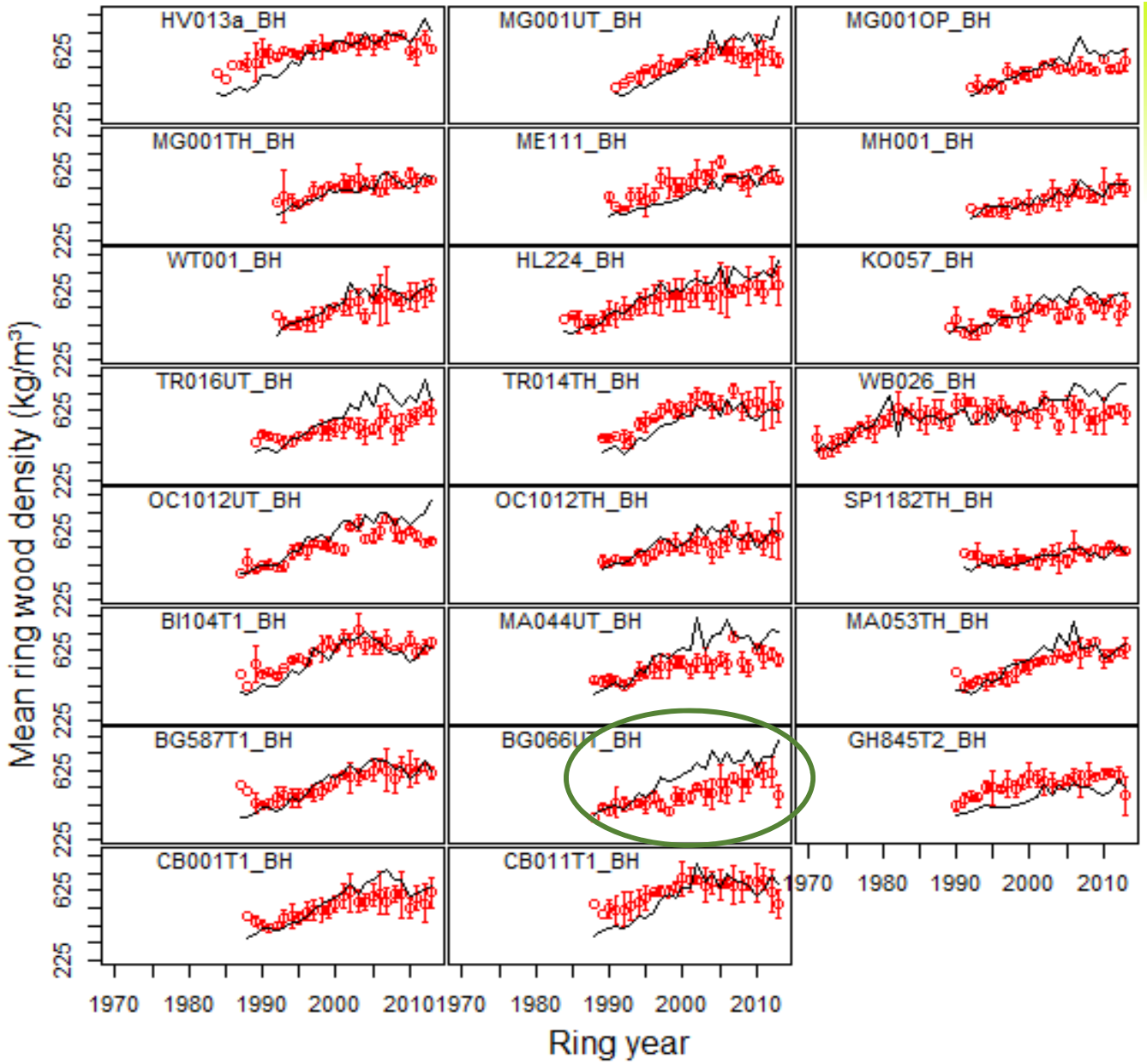




Forest Quality
MORE VALUABLE TREES

Radial trends

Comparison with actual Silviscan data allowed eCambium to be evaluated at the annual ring level to assess whether the model was predicting radial trends accurately.

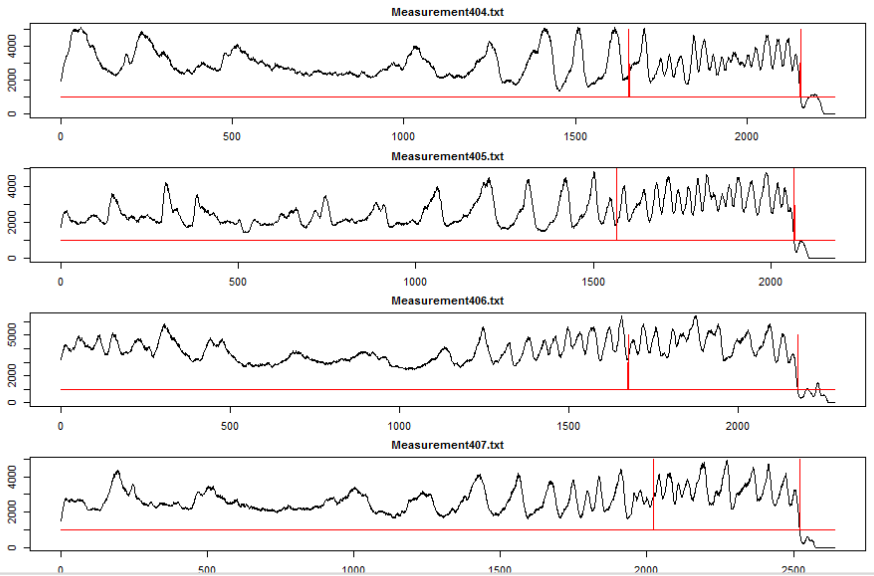


Forest & Wood Products Australia

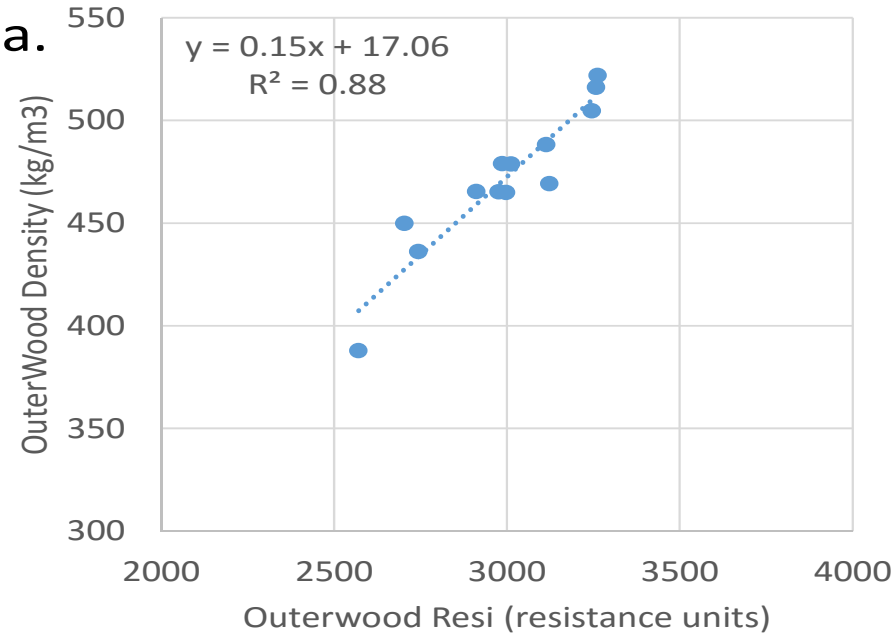
Forest Quality
MORE VALUABLE TREES

IML Resistograph

- < 30 secs per tree
- Provides radial variation
- No Laboratory work
- Easy –to-use



a.



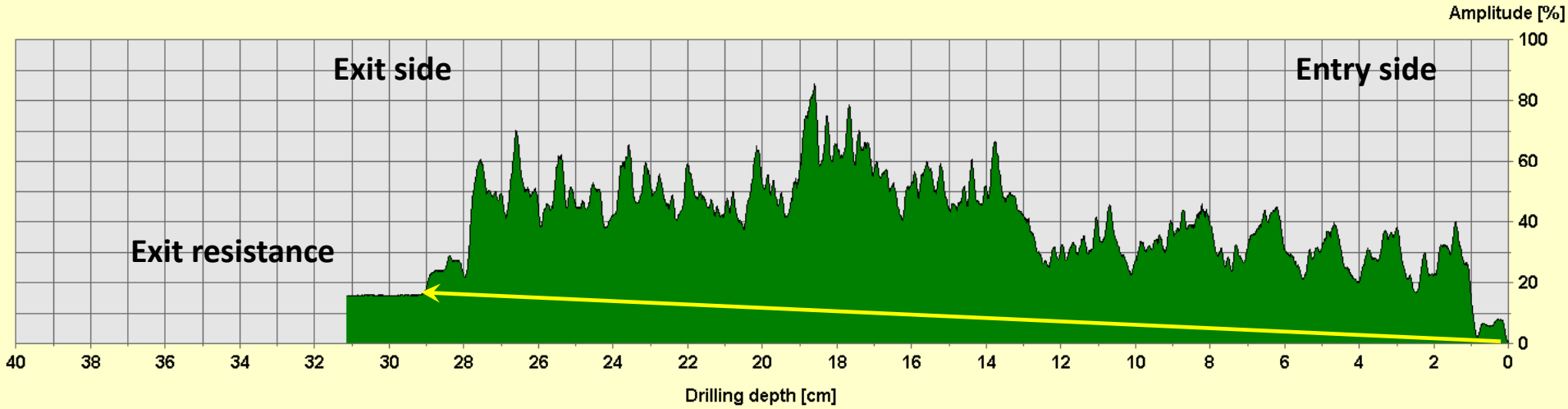
Forest & Wood Products Australia

Forest Quality

MORE VALUABLE TREES

Measuring / object data

Measurement no.	: 161	Needle speed	: 2500 r/min	Diameter	:
ID number	: 05/25/04	Needle state	: ---	Level	:
Drilling depth	: 31,15 cm	Tilt	: ---	Direction	:
Date	: 03.11.2016	Offset	: 88/300	Species	:
Time	: 12:14:56	Avg. curve	: off	Location	:
Feed speed	: 150 cm/min			Name	:



Assessment

☐	From	0,0 cm	to	0,0 cm :
☐	From	0,0 cm	to	0,0 cm :
☐	From	0,0 cm	to	0,0 cm :
☐	From	0,0 cm	to	0,0 cm :
☐	From	0,0 cm	to	0,0 cm :
☐	From	0,0 cm	to	0,0 cm :

70% of exit resistance explained by diameter (~50%) and density (~20%)

Comment

FORICO NKING05

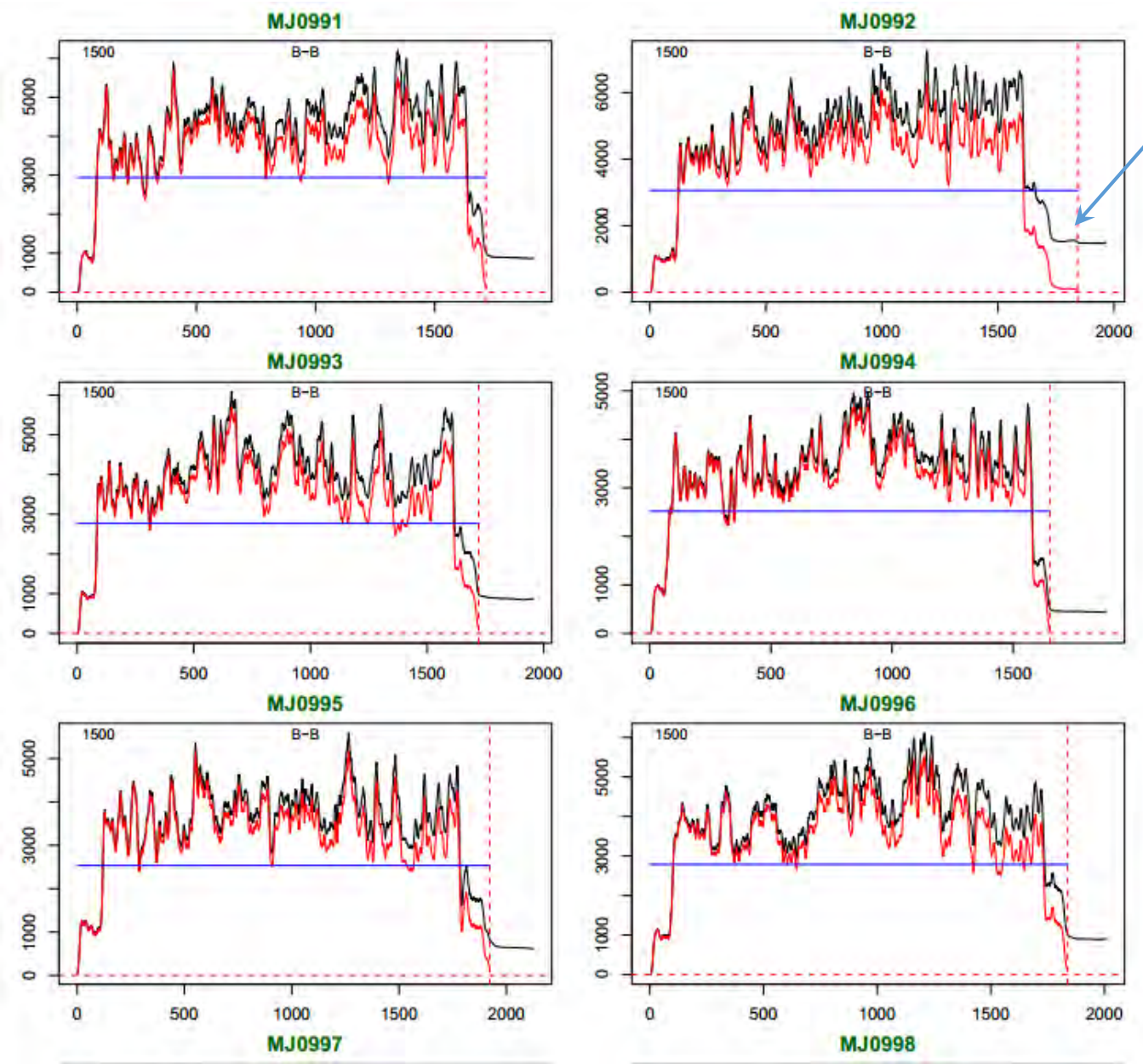
Forest & Products Australia

Forest Quality

MORE VALUABLE TREES

Properties obtained

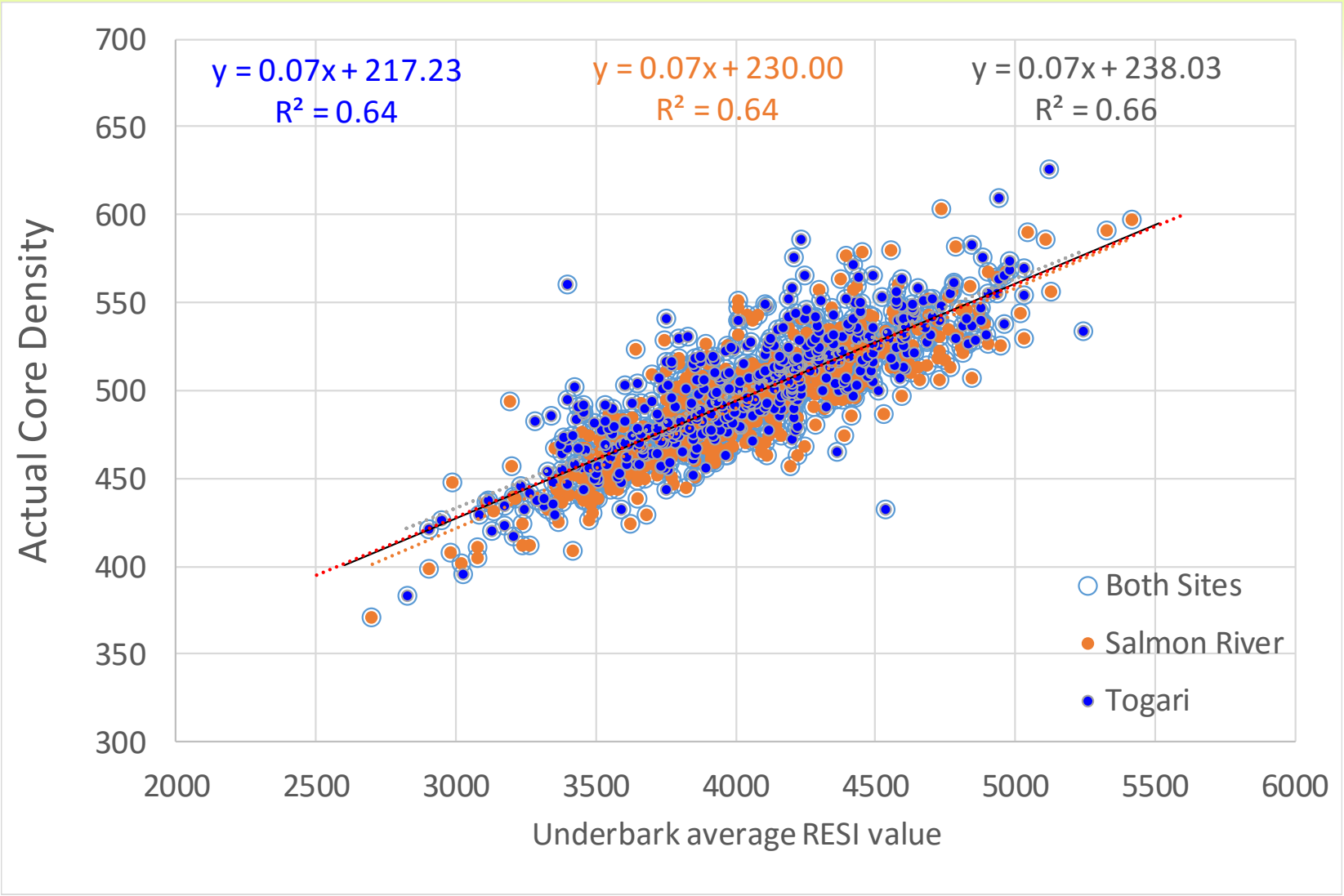
- Overbark diameter
- Underbark diameter
- Bark thickness
- Average underbark density
- Outerwood averages
- Radial average



Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

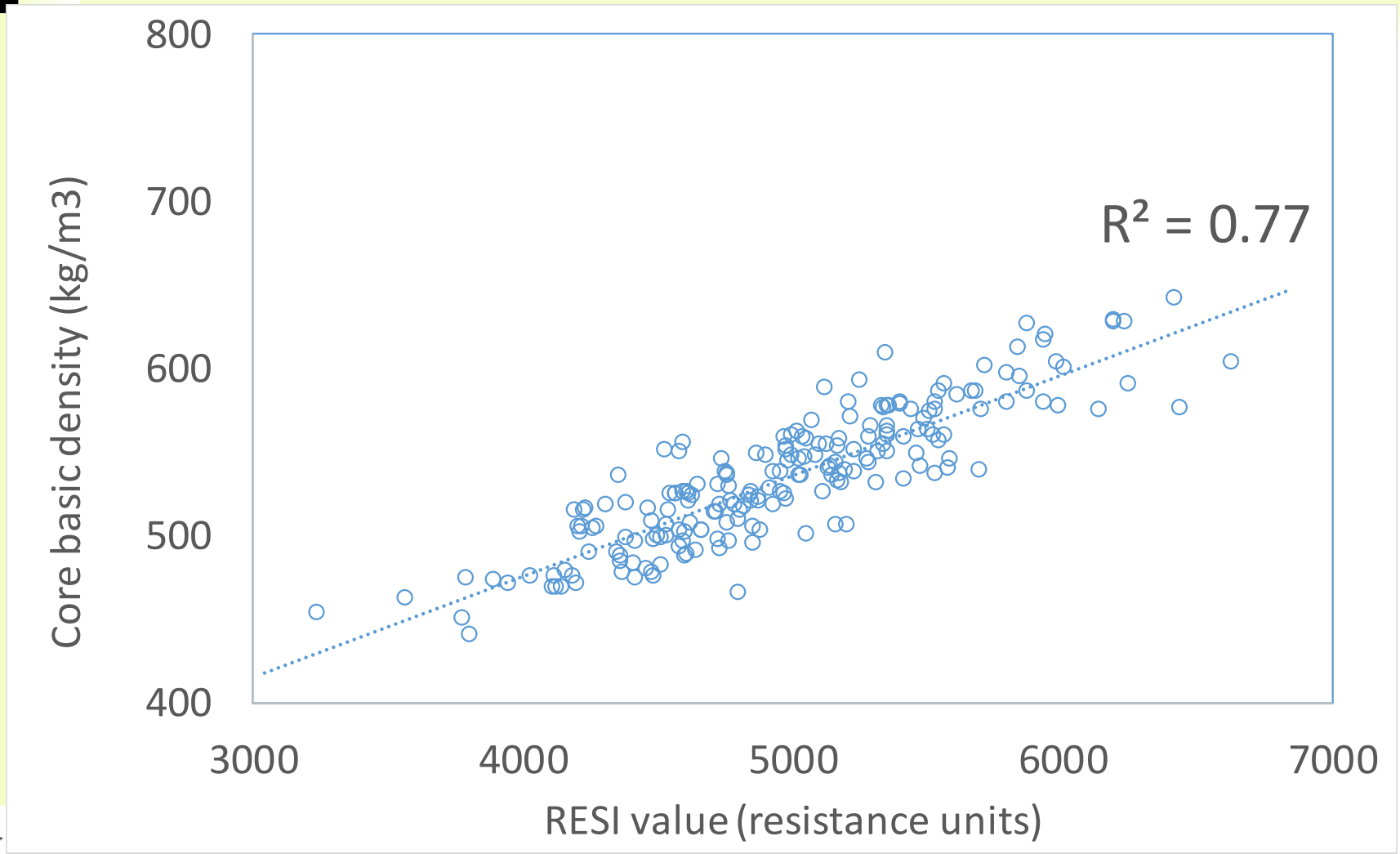
ARC study: University of Tasmania (Prof Brad Potts)



Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Manjimup, WA Resi Validation



Forest & Wood Products Australia

Resi analysis 16 Jan 2017: DB name : C:\Users\Owner\Dropbox\FQ Projects\FQ110 USC FWPA RESI SYP\FQ110 SYP All Sites Master copy.mdb

Projects and Data Input

Create a new project

Open an existing project

Import Resi data files

Add or edit sample info

Sample name	PrHM200 (km/s)	PrDensity (kg/m	PrMOE (GPa)	Parameter Set	Sample posi	Tree ID	Tree type	DBH (cm)	Site name	Resi speed (rp	Resi feed rate
1_1-11-7	3.72	526.5	14.6	Default							
1_1-12-6	4.04	510.9	16.7	Default							
1_1-1-6	3.75	504.5	14.2	Default							
1_1-2-6	3.82	488.5	14.3	Default							
1_1-4-6	3.48	494.2	12	Default							
1_1-6-6	3.72	511.6	14.1	Default							
1_1-8-6	3.69	547.8	14.9	Default							
1_2-10-6	3.99	583.5	18.6	Default							

Allocate pith, cambial position and annual rings

Manually select:

Pith Rings CZone

Select a Resi sample: 34_1-11-7

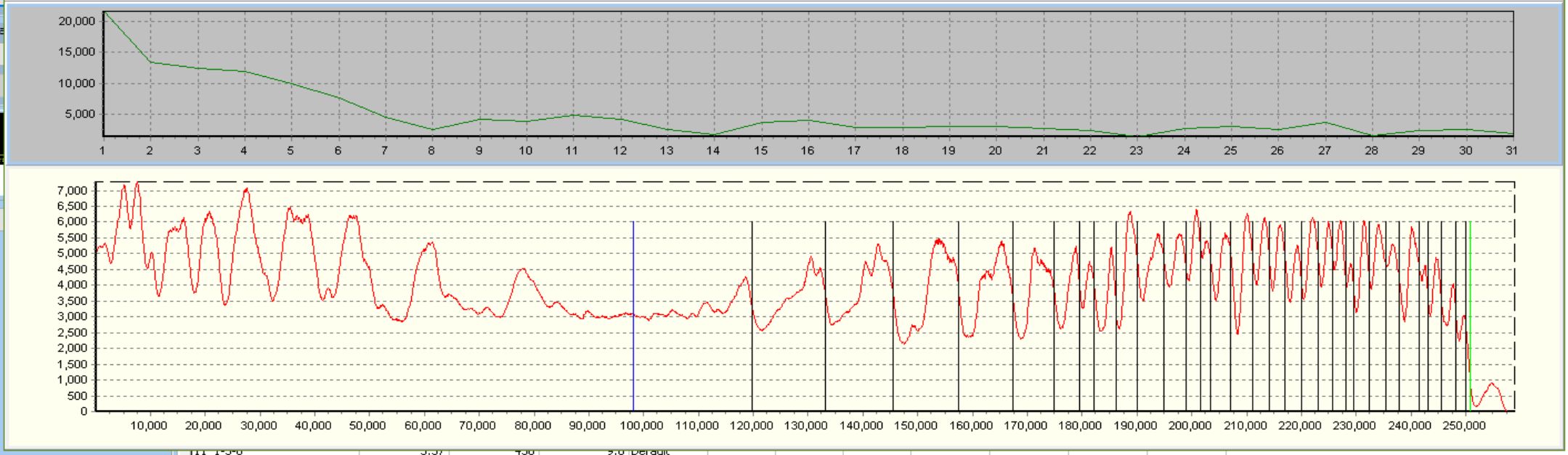
Select a parameter set: Default

Calculate HM200 value Delete Sample

Last Sample...34_1-13-6

Select to use existing rings

Select a sample to compare:



11_2-11-6	4.03	504.6	16.4	Default							
11_2-12-6	3.38	449.5	10.3	Default							
11_2-13-6	3.69	500.3	13.6	Default							
11_2-14-6	3.5	450.8	11.1	Default							

Check parameters

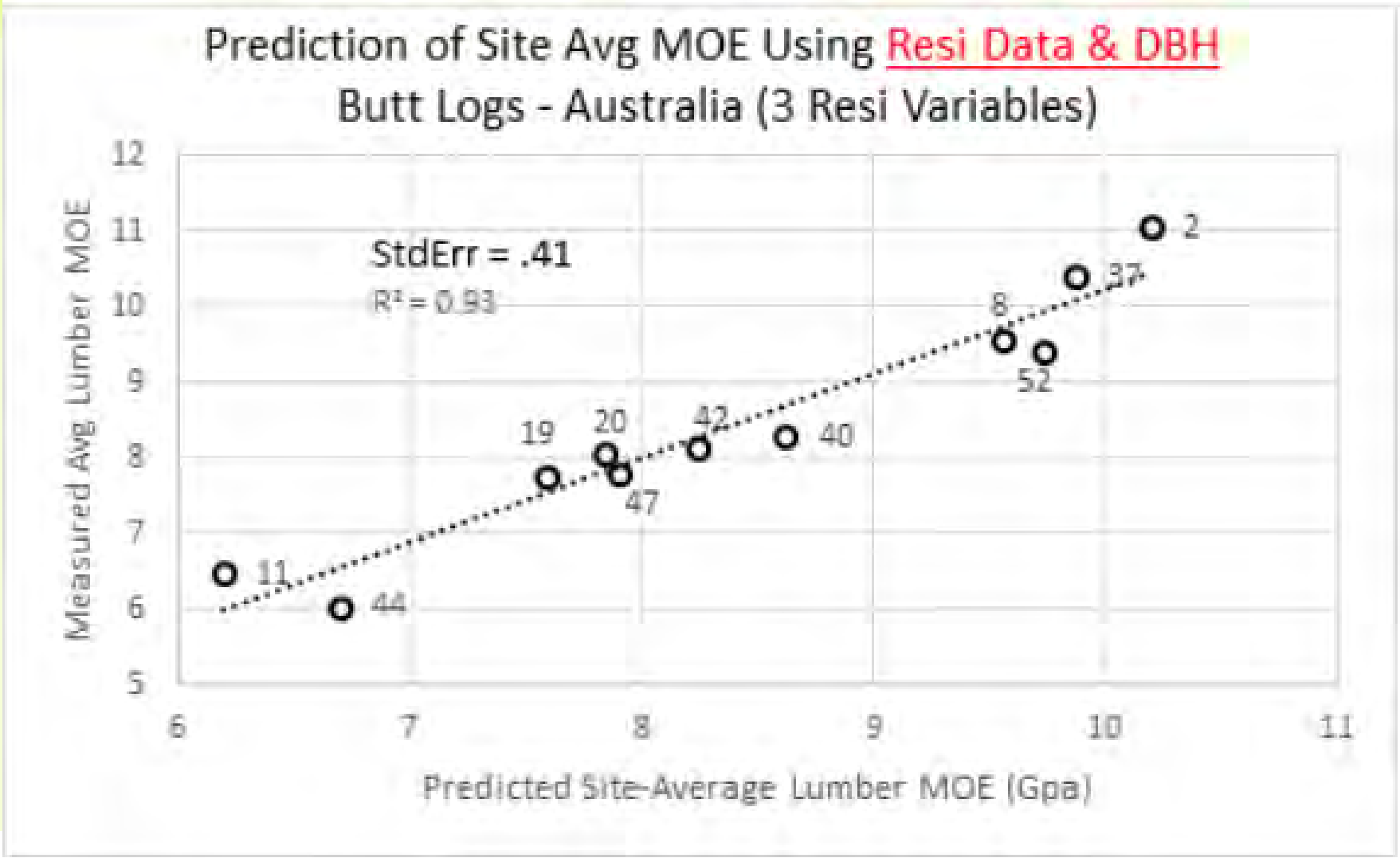
Clear the log

Compact Database

1/18/2017 8:30:37 PM: Calculations for 34_1-13-6 completed. PrHM200 = 4.13409617750339
1/18/2017 8:30:35 PM: Calculations for 34_1-1-6 completed. PrHM200 = 3.92390776035512
1/18/2017 8:30:29 PM: Calculations for 34_1-13-6 completed. PrHM200 = 4.13409617750339
1/18/2017 8:30:27 PM: Calculations for 34_1-11-7 completed. PrHM200 = 3.97928336378193
1/18/2017 8:30:25 PM: Calculations for 1_1-11-7 completed. PrHM200 = 3.72100179283597

Forest Quality

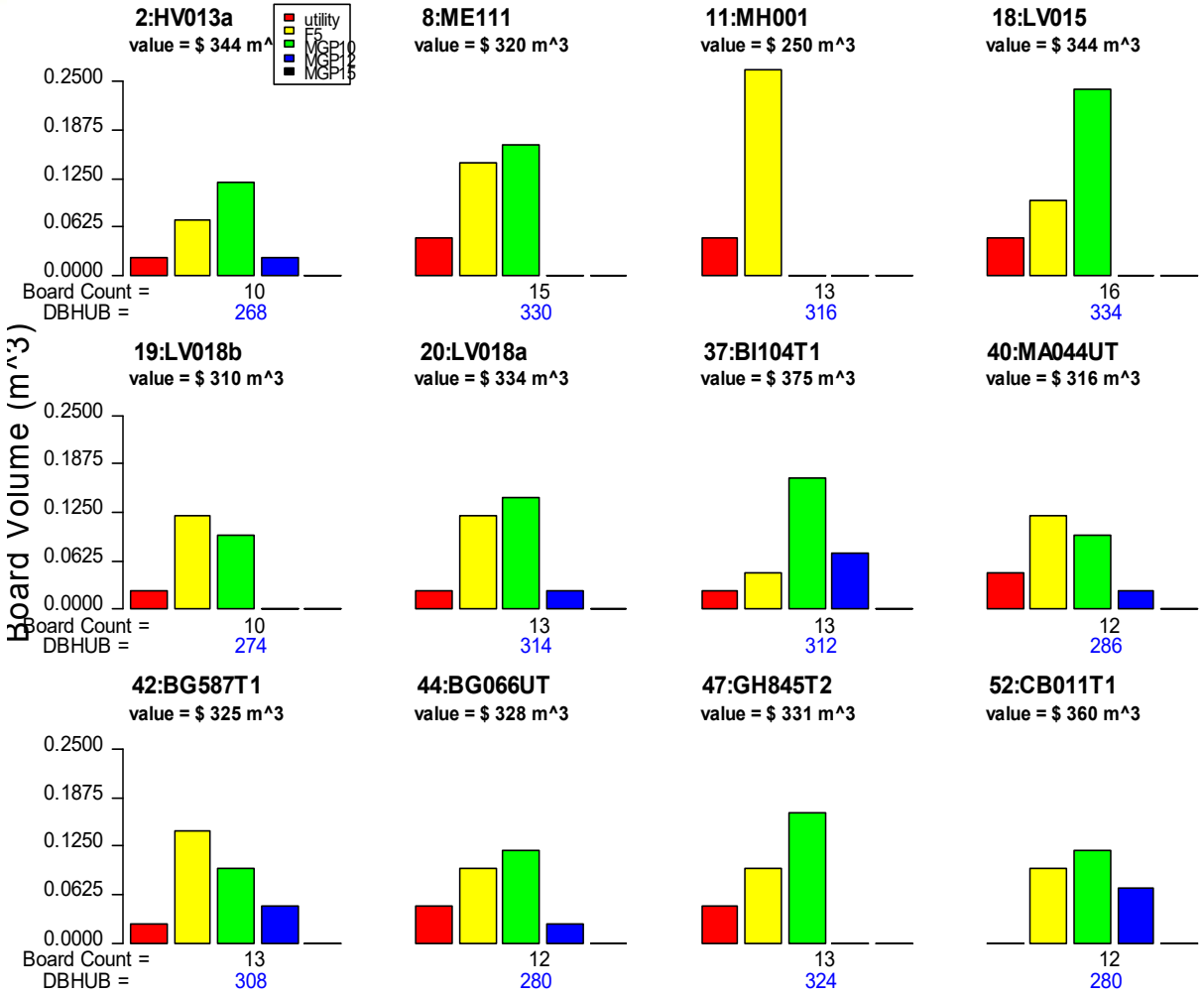
MORE VALUABLE TREES



Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Sawmill study sites value predictions



Forest & Wood Products Australia

Forest Quality

MORE VALUABLE TREES

Log Preparation

Forest & Products

Forest Quality
MORE VALUABLE TREES

Logs weighed for green density calculation

Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

Logs loaded into mill infeed

Forest & Wood Products Australia

Forest Quality

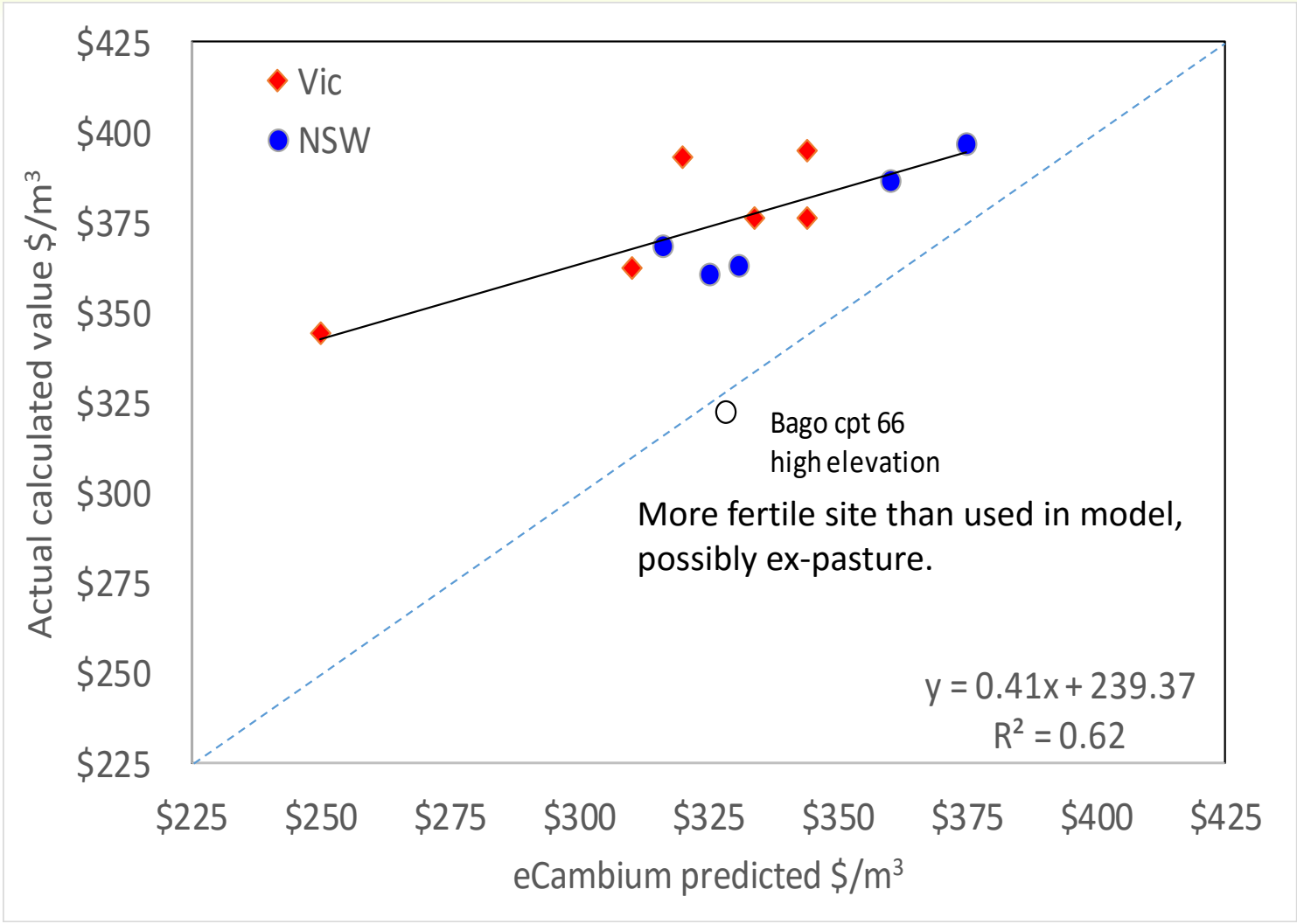
MORE VALUABLE TREES

Resultant boards imaged

Forest Quality
MORE VALUABLE TREES

eCambium's prediction of site value

- eCambium predictions made 4 months before logs were harvested
- Partly dependent on grade thresholds for converting MOE into grade



Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

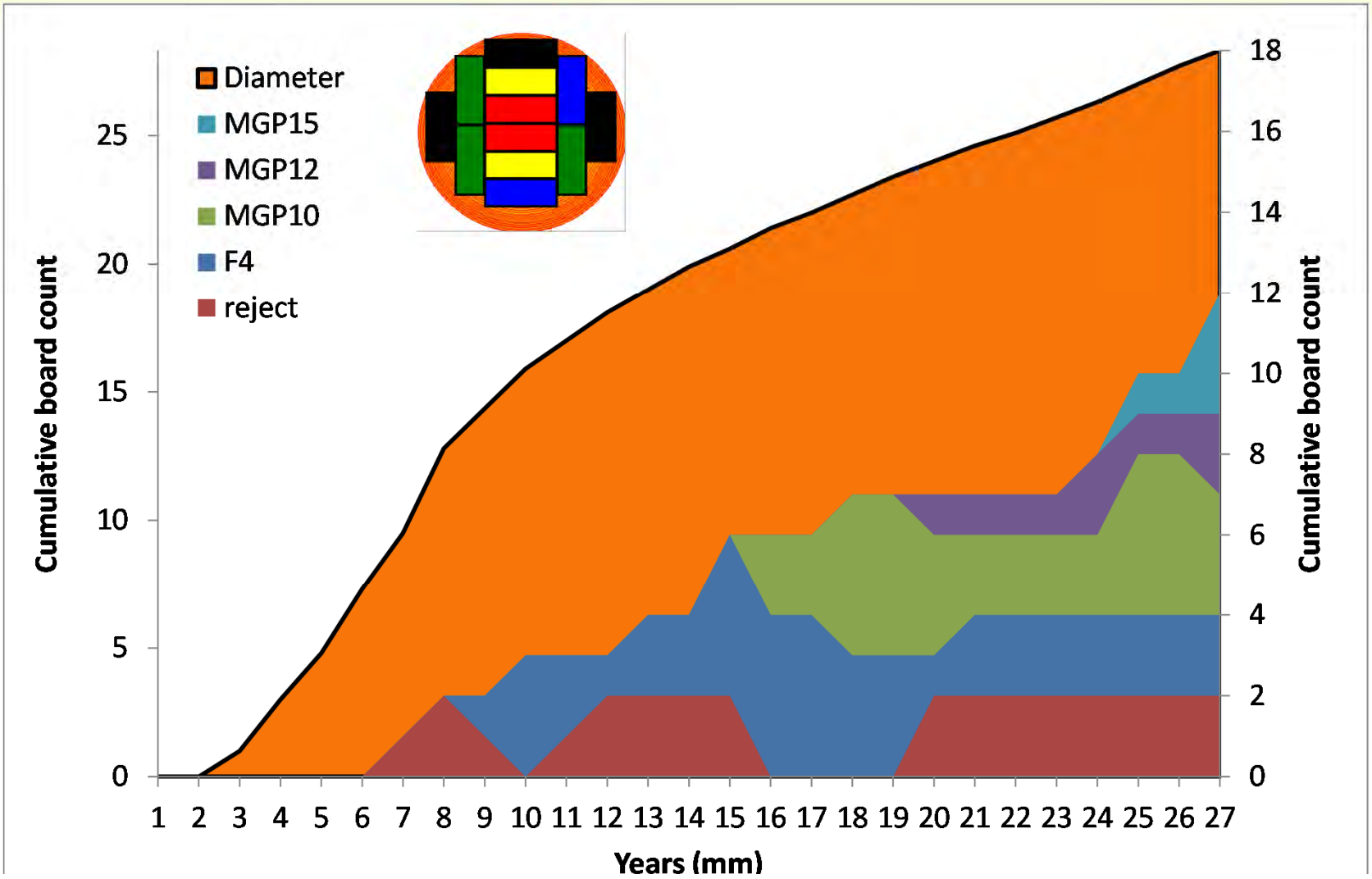
Conclusions

- eCambium explained similar OWD variance to empirical models
  - eCambium predictions in range using general inputs for site descriptions
    - publically available database values
    - FR constant at 0.3,
    - rock content constant at zero
  - Parameter optimization, across Tasmania, Green Triangle, Victoria and NSW yielded calibration $r^2 > 60\%$
- eCambium explained 50-60% of the site average sawlog value and log MOE
  - Low-cost way to get broad-scale insights into estate-level wood variation and value
- Model setup and operation relatively simple
  - Ready for commercial application
  - Development for operational functionality needed (industry input required)

Forest & Wood Products Australia

Forest Quality
MORE VALUABLE TREES

e-Cambium: options for the future



Forest & Wood Products Australia