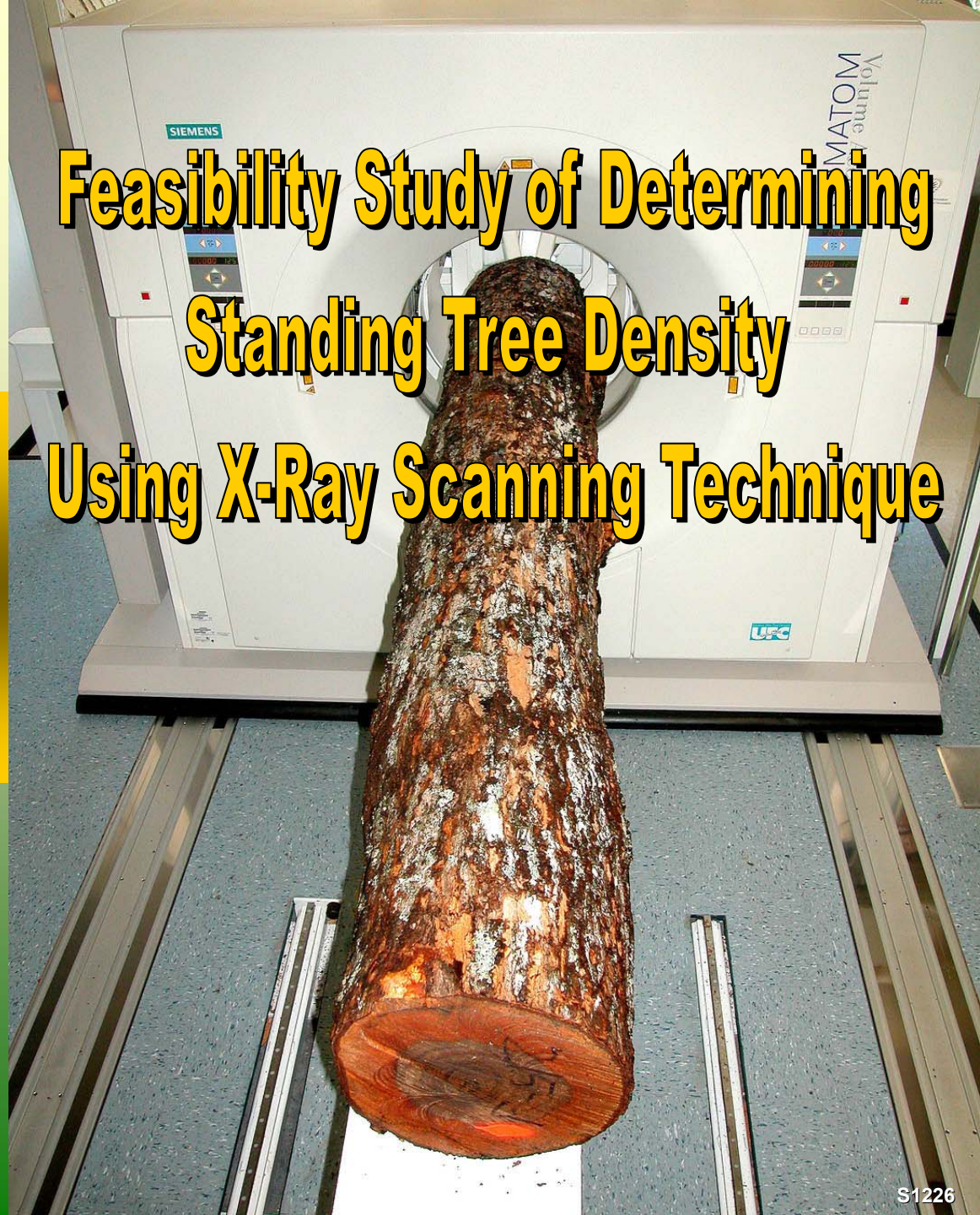




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**Feasibility Study of Determining
Standing Tree Density
Using X-Ray Scanning Technique**



Background

Standing Tree Density

- **Affect wood properties and end uses**
- **Little work done**

X-ray Scanning Technique to Determine Density

- **Lumber**
- **Composite wood panels**

Computer Tomography (CT) X-Ray Scanning Technique

- **Images of inside of logs**



Objective

**Examine the feasibility of
determining standing tree
density using X-ray scanning
technique**



Materials

**Fresh logs
from beech and
baslsam fir**

Resource Assessment and Utilization



Experimental Procedure

- 1) Cut butt logs from standing trees and sealed logs in plastic bags**
- 2) CT X-ray scanning using Siemens's SOMATOM Plus 4 Volume Zoom computer tomography (CT) system for multi-slice spiral scanning**
- 3) Destructive determination of log density using 51 mm (2 in.) discs cut from the log specimens**



Experimental Procedure

- 4) **Determination of moisture contents of the discs using oven dry method**
- 5) **Analysis of X-ray attenuations (CT numbers) measured by CT scanner using Matlab program**
- 6) **Development of prediction equations for fresh log density from CT number by linear regression analysis**



**Siemens's SOMATOM Plus 4
Volume Zoom CT X-Ray
System**



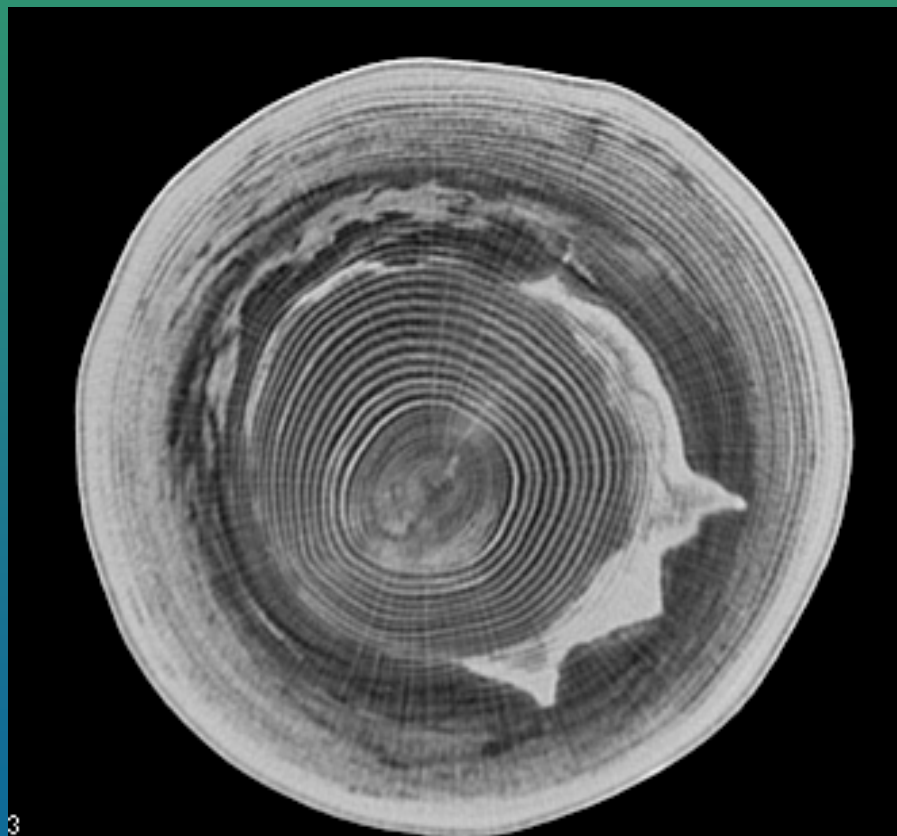
Parameters for CT X-Ray Scanning Log Specimens

- X-ray tube kilovoltage: 140 kVp
- X-ray tube current: 178 mA
- Volume element of the section that was scanned (voxel) of $0.78 \times 0.78 \times 10.00 \text{ mm}^3$
- Interval of reconstructed sliced images along the longitudinal direction of the log: 51 mm (two inches)

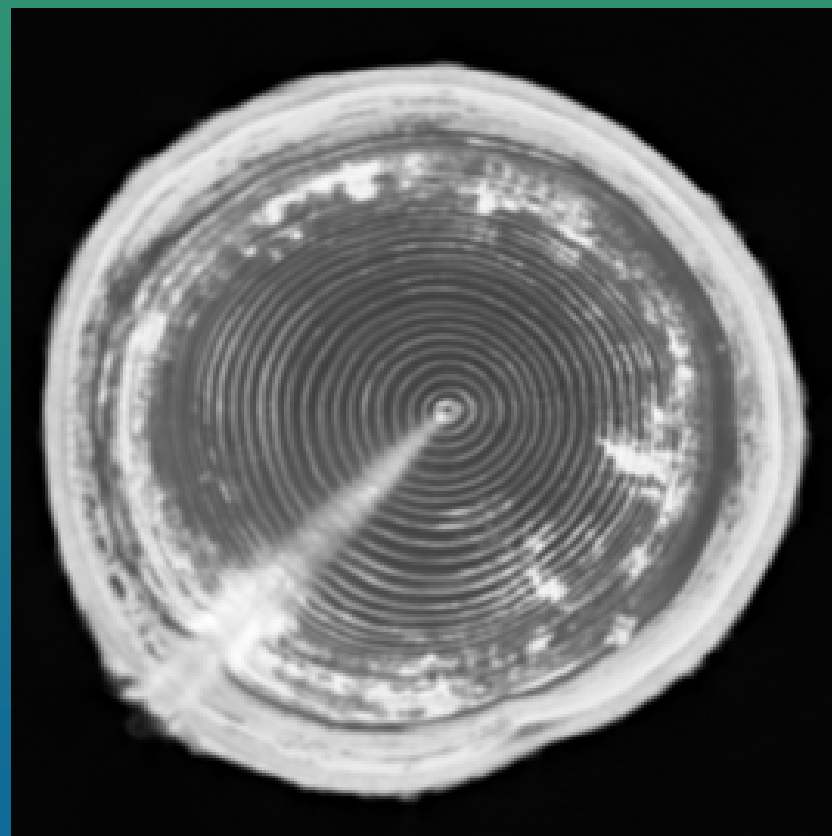


Image of Cross-Section of Log Specimen

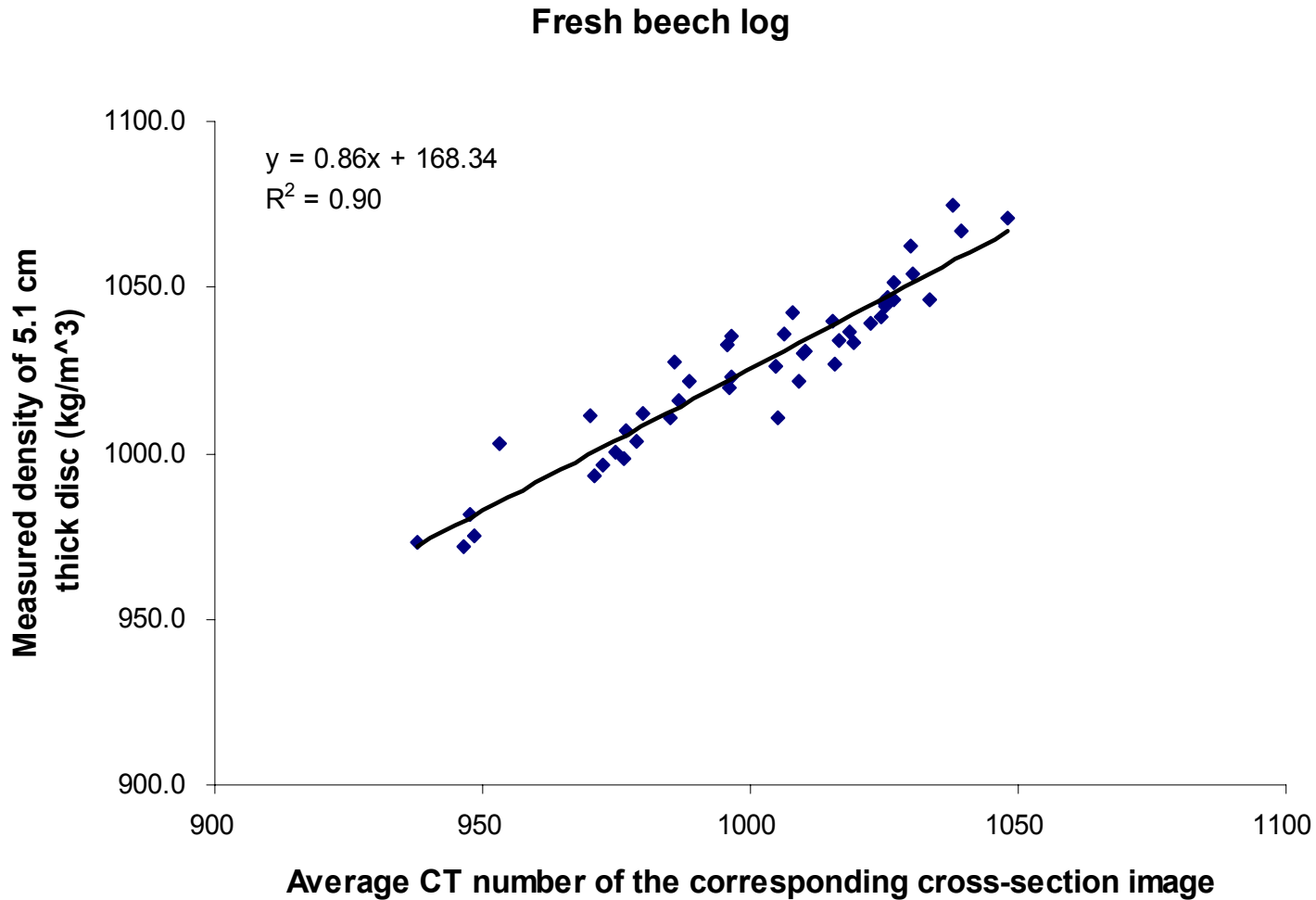
Beech



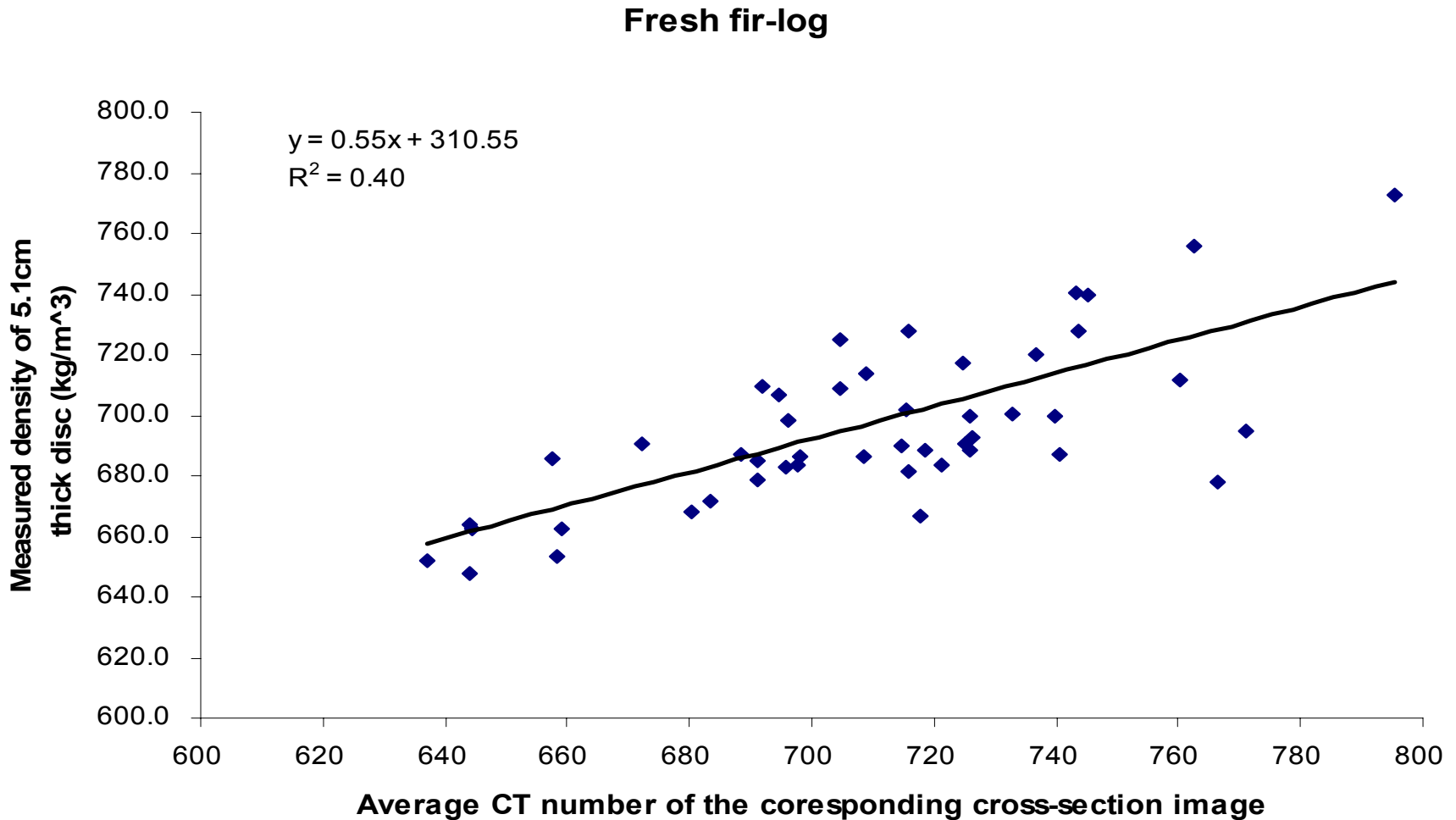
Fir



Relationship between fresh log density and X-ray attenuation



Relationship between fresh log density and X-ray attenuation





Discrepancy of predicted density from measured density (%)

Log species	Absolute Mean	Maximum	Minimum
Fresh beech	0.7	2.2	-1.5
Fresh fir	2.5	8.0	-12.2



Factors Affecting the Accuracy

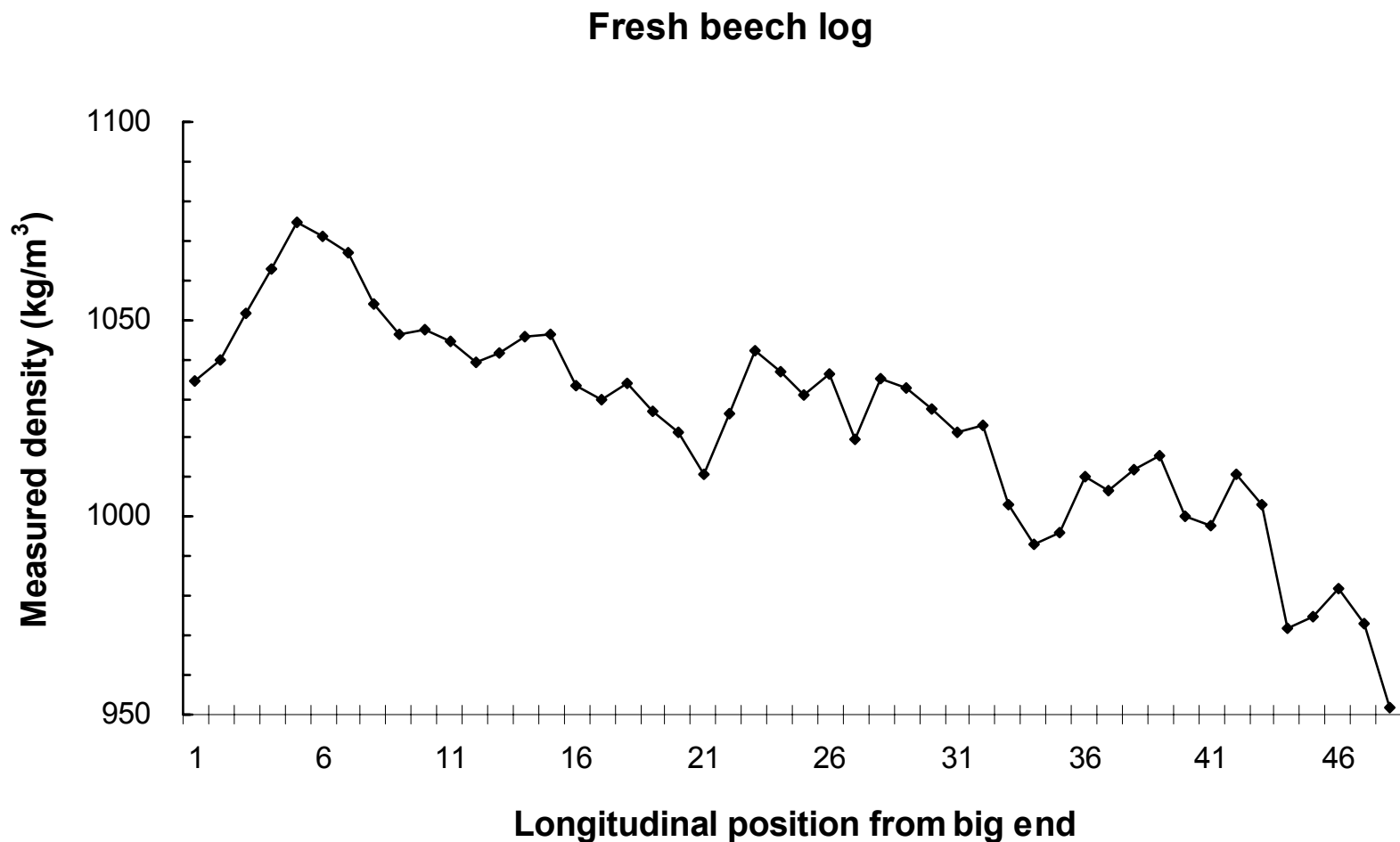
Uniformity of Density Distribution

Log species	Coefficient Variance (%)	
	Longitudinal	Radial
Fresh beech log	2.6	9.6
Fresh fir log	4.3	16.9

Moisture Content (%)

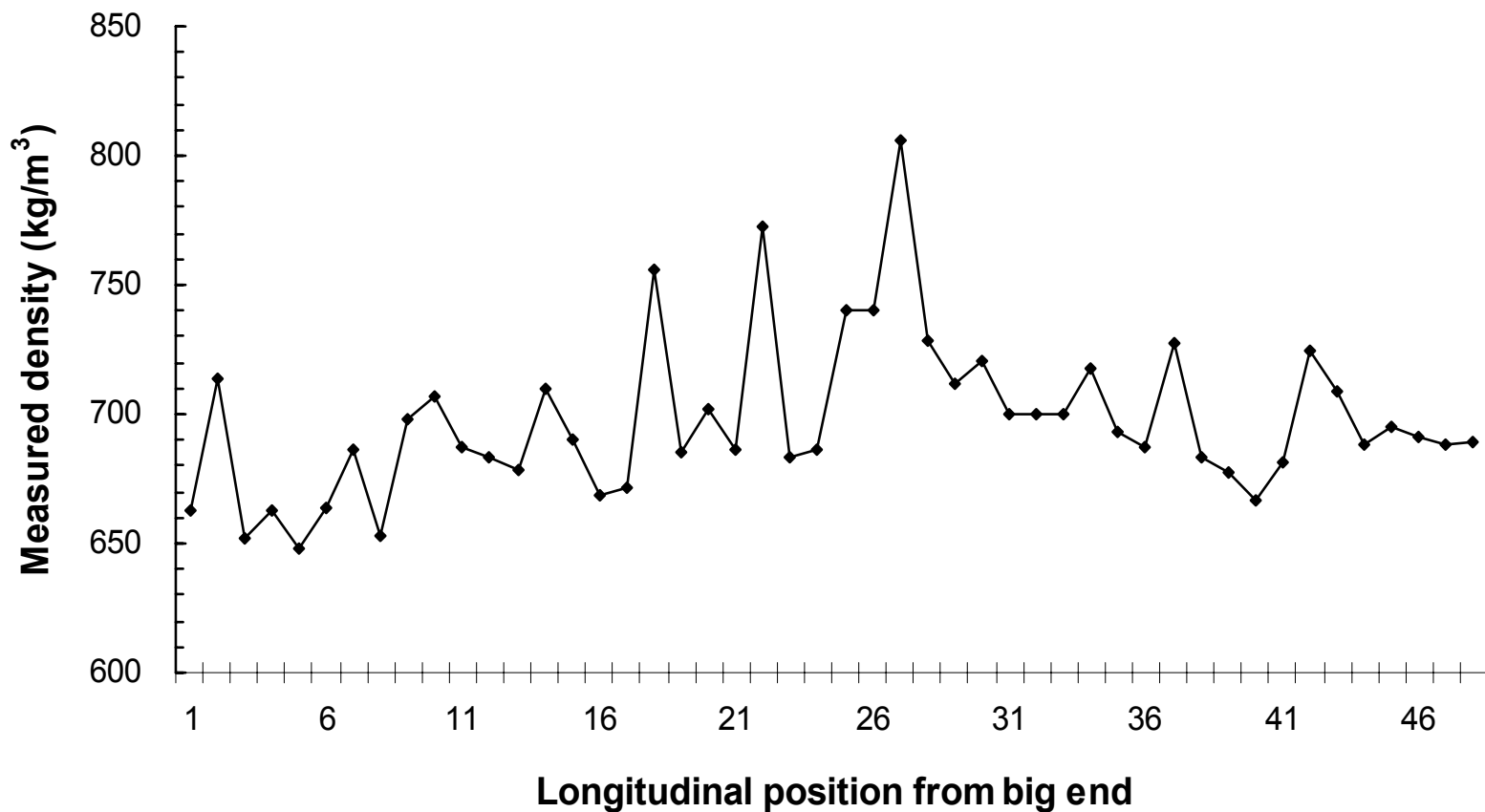
Log species	Average	Standard Deviation	Coefficient Variation (%)
Fresh beech	68.5	1.4	2.0
Fresh fir	107.5	7.2	6.7

Longitudinal Density Distribution

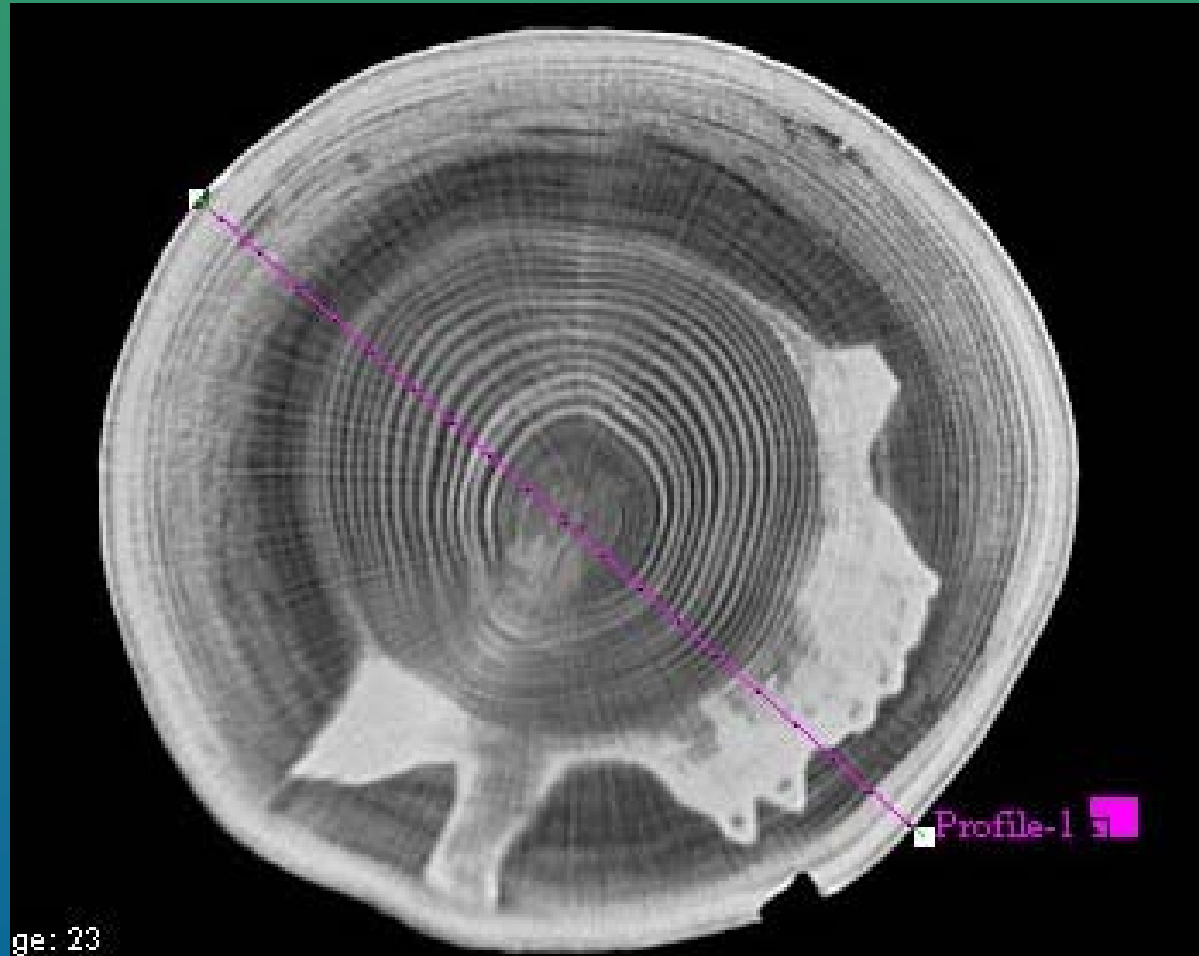


Longitudinal Density Distribution

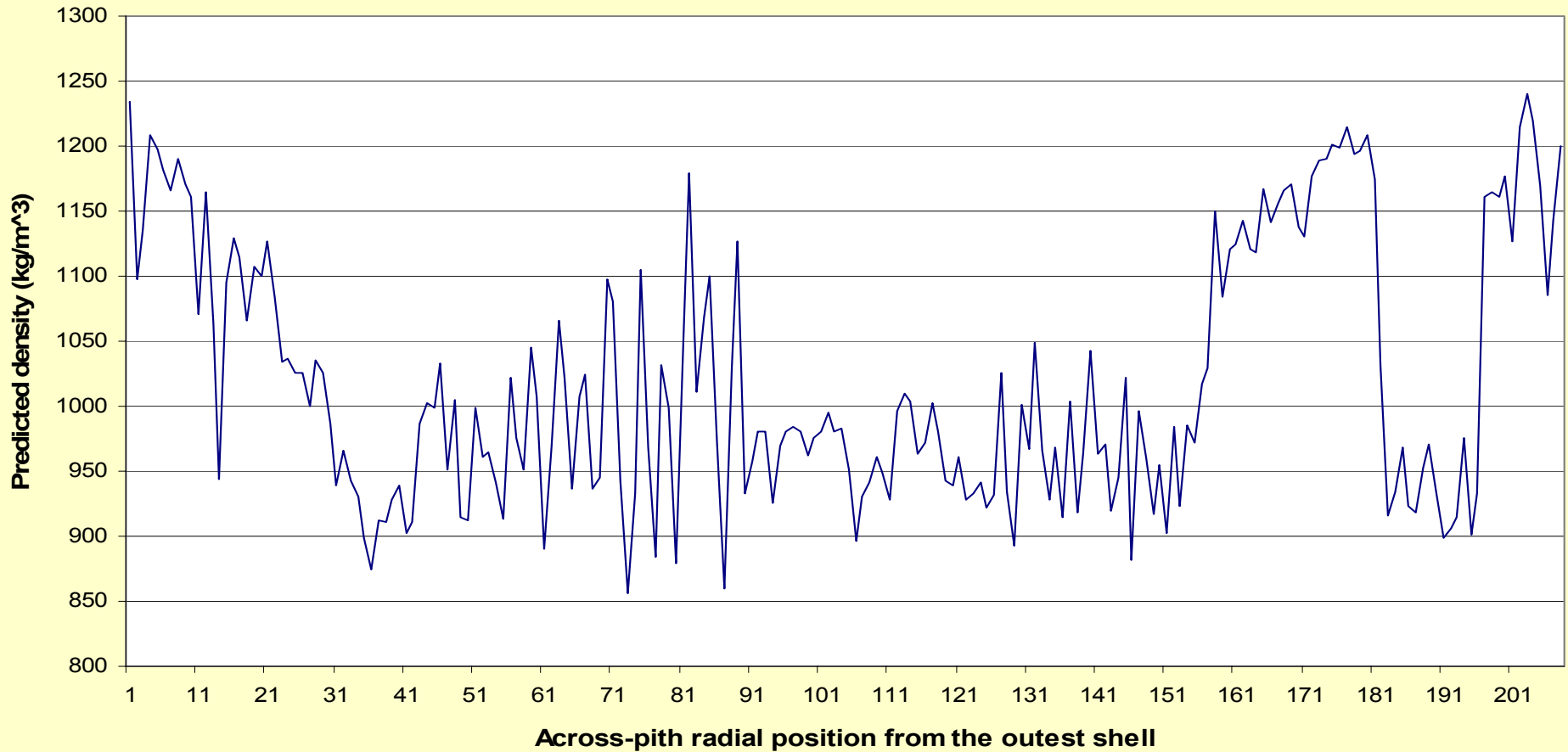
Fresh fir log



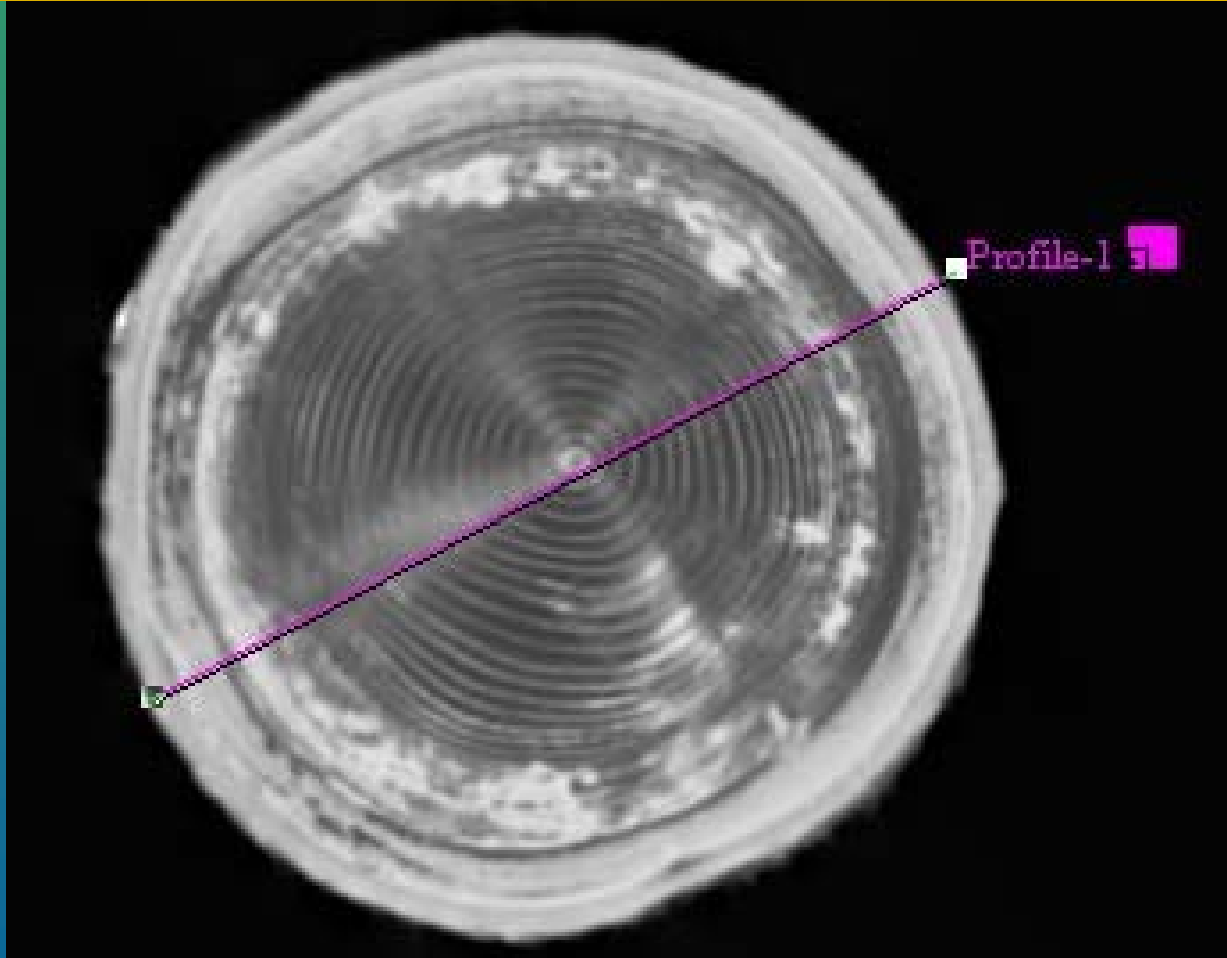
Prediction of Radial Density Distribution Along Profile-1 of a Cross-Section of Fresh Beech Log Specimen



Across-Pith Radial Density Distribution Along Profile-1 of a Fresh-Beech Log Cross-Section

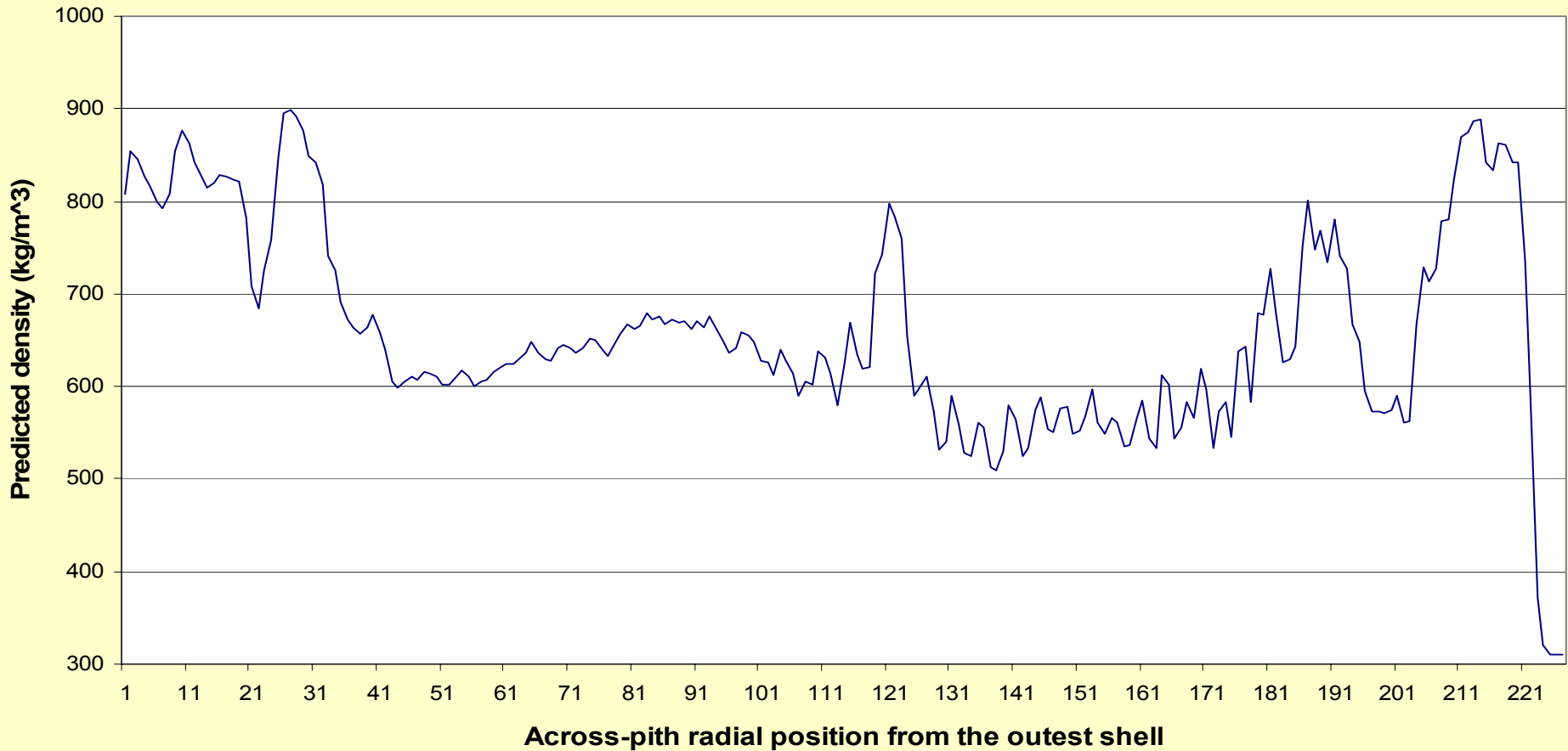


Prediction of Radial Density Distribution Along Profile-1 of a Cross-Section of Fresh Fir Log Specimen



Resource Assessment and Utilization

Across-Pith Radial Density Distribution Along Profile-1 of a Fresh-Fir Log Cross-Section





Conclusion & Recommendation

- 1) X-ray scanning is a promising technique to non-destructively determine fresh log density**
- 2) Portable X-ray device is needed for standing tree density determination**
- 3) Further research is needed to improve the accuracy and effectiveness of its application to various species of standing trees**

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